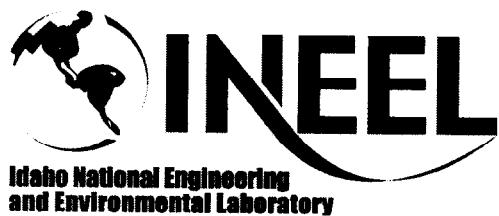


Engineering Design File

SSSTF Design Radiological Control Analysis

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho



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Page 1 of 1

1. Title: SSSTF Design Radiological Control Analysis				
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3. Site Area and Building No.:		4. SSC Identification/Equipment Tag No.:		
5. Summary: Contaminated soil will be transported through the Staging, Storage, Sizing, and Treatment Facility (SSSTF). Some of this soil will receive stabilization treatment within the SSSTF. Also decontamination of equipment will be performed. This Engineering Design File (EDF) addresses the radiological control (RadCon) issues of these activities. The results of the review of radiological control issues are documented per this EDF. The radiological control requirements involving worker safety are identified. The completed Radiological Control Design Review form is contained in this EDF. The radiation source terms are analyzed and bounded. The bounding analysis provides a basis for the adequacy of the design for RadCon requirements. The requirements are that radiation is to be controlled at the source. With adequate ventilation, including high-efficiency particulate air (HEPA) filters, containment and shielding, contamination control, and monitoring with fixed and portable radiological control instruments, the SSSTF design will adequately control the radiation at the source.				
6. Review (R) and Approval (A) and Acceptance (Ac) Signatures: (See instructions for definitions of terms and significance of signatures.)				
	R/A	Typed Name/Organization	Signature	Date
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9. Registered Professional Engineer's Stamp (if required)				

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	as low as reasonably achievable
AMAD	average median aerodynamic diameter
CAM	continuous air monitor
CEDE	committed effective dose equivalent
CWID	CERCLA Waste Inventory Database
DAC	derived air concentration
EDF	Engineering Design File
EPA	Environmental Protection Agency
HEPA	high-efficiency particulate air
HPIL	Health Physics Instrument Laboratory
ICDF	INEEL CERCLA Disposal Facility
ICPP	Idaho Chemical Processing Plant
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MCP	management control procedure
PCM	personnel contamination monitor
PPE	personal protective equipment
RadCon	radiological control
RCM	Radiological Control Manual
RCT	radiological control technician
SSSTF	Staging, Storage, Sizing, and Treatment Facility
TEDE	total effective dose equivalent
TFR	technical and functional requirements
TLV	threshold limit values

SSSTF Design Radiological Control Analysis

1. PURPOSE AND OBJECTIVE

Contaminated soil will be transported through the Staging, Storage, Sizing, and Treatment Facility (SSSTF) at the Idaho National Engineering and Environmental Laboratory (INEEL). Some of this soil will receive stabilization treatment within the SSSTF. Also, decontamination of equipment will be performed. The final objective of this Engineering Design File (EDF) is to document the review of radiological control (RadCon) issues and the radiation risk of the SSSTF. The requirements that are pertinent to the design are documented. The RadCon requirements in this EDF are more detailed than the RadCon requirements in the technical and functional requirements (TFRs) and some are only indirectly applicable. This listing was necessary to analyze the overall radiation risk to workers. This review and analysis of the radiation risk are documented in this EDF in the following format:

- Section 2 identifies the RadCon issues of the SSSTF and the expected radiation risk to worker safety.
- Section 3 provides a bounding analysis of the worst-case external radiation exposure rate.
- Section 4 presents the maximum internal radiation dose that can be expected.
- Section 5 analyzes waste streams from CPP-92, CPP-98, and CPP-99 in the stabilization process for external radiation.
- Section 6 is similar to Section 4 but presents a worst-case bounding analysis for waste streams from CPP-92, CPP-98, and CPP-99 for internal radiation exposure.
- Section 7 presents an analysis that bounds expected loose surface contamination that will result in a Contamination Area.
- Section 8 describes the RadCon instrumentation that is required for both the SSSTF and INEEL CERCLA Disposal Facility (ICDF).

Several appendices provide supporting information:

- Appendix A gives radiological control requirements.
- Appendix B is a radiological control design review form.
- Appendices C through F are results of MicroShield analyses for various exposure rates (from a dump truck, from an unshielded box, and for various thicknesses of iron).
- Appendix G describes how waste stream CFA-04 falls within the evaluation of waste streams CPP-92, CPP-98, and CPP-99 and needs no further evaluation.

2. REVIEW OF SSSTF DESIGN RADIOLOGICAL CONTROL ISSUES

A review of radiological control issues has been performed for the SSSTF design. Appendix A lists the applicable regulatory radiological control requirements for worker safety. The results of the review are given in the remainder of this section.

Within the SSSTF, the highest direct radiation risk is from the trucks containing contaminated soil. The loaded trucks may stop at the entrance, be in a holding queue, stop on the weighing scale, or be driven through the SSSTF to the ICDF. The potential direct radiation is high enough that shielding for the truck driver may be required. Also, the area around the truck holding queue and the pathway along which the trucks will move will need to be controlled. These areas could be Radiation Areas or High Radiation Areas. For the worst case, the boundary of a Radiation Area would be 60 ft from a single loaded truck.

For normal operations, the risk to workers from internal radiation exposure from loaded trucks will be less than direct radiation. The worst-case internal radiation exposure was determined. A small amount of airborne dust ($43 \mu\text{g}/\text{m}^3$) could result in continuous occupancy limits being reached. Although this is conservative and considered the worst case, it shows that the soil on loaded trucks will probably need to be damp, sealed in a burrito-type bag or equivalent, and tared. Before operation, the specific engineering controls will need to be evaluated.

Within the SSSTF, the area that has the most internal radiological risk is the stabilization area within the decontamination facility. This is because containers of contaminated soil will be opened. Radiologically-contaminated soil will be stabilized at the SSSTF. The waste streams that have been identified as possibly requiring processing through the stabilization area were analyzed and include CPP-92, CPP-98, and CPP-99. Two different processes are involved with stabilization of these waste streams. The first process involves only contaminated soil. A mixer unit will be used to stabilize this soil. A commercial vendor will design and install the mixer unit. The second process involves contaminated debris. The debris consists of contaminated pipe, concrete, wood shoring, etc. This will not be removed from the containers that the waste is received in. Currently, the plan is to put several holes in the containers. A stabilization agent will be input into the one hole until it comes out the second hole. An evaluation of the emissions from the second holes may require a funnel connected to a separate ventilation system from the building ventilation system to be placed over the second hole.

A commercial mixer will be used to stabilize radioactive contaminated soil that is not mixed with debris. The mixer will be located within the decontamination facility. The soil will be mixed with a reagent along with water. Three waste streams, (CPP-92, CPP-98, and CPP-99) may require stabilization. The contaminated soil is contained within $2 \times 4 \times 8$ -ft and $4 \times 4 \times 8$ -ft wood boxes. The boxes will be emptied into the mixer. After stabilization is performed, the resulting mixture may be placed back into the original boxes. Other types of containers may be used. The treated waste will then be sampled (as necessary), staged, transported, and disposed in the ICDF. Other waste streams may also be treated in the treatment facility.

Although a commercial vendor will design and install the mixer unit, a bounding analysis is needed to envelope the RadCon issues. Also, the bounding analysis will be used to assist in reviewing the vendor's design for adequacy in meeting the RadCon requirements. Two specific bounding analyses were performed. One concerns shielding of direct radiation. It is used to provide a basis for requiring shielding. The details of this analysis are in Section 5.

The second bounding analysis is an airborne analysis of the fugitive dust from the mixing unit containment. This provides a basis for requiring the mixing unit to have containment and ventilation. The details of this analysis are in Section 6.

The design will include shielding, containment, and ventilation. To assist in evaluating the radiation hazards to workers, the bounding analyses were performed for both external and internal radiation dose. The approach that was taken was to determine how rigorous the barriers need to be so the dose is within the allowed limits.

In the analysis, each specific radionuclide identified was listed. Then, the highest specific activity in all of the waste streams for each identified radionuclide was determined. Specific activity for this document is defined as the amount of radioactivity per mass of some material (i.e., radionuclide concentration). It is the radioactivity concentration in that material. This list then comprises all identified radionuclides and the corresponding highest specific activity. Waste stream CPP-92 for each radionuclide has the highest specific activity. CPP-92 waste stream was used in bounding calculations for radiological control issues for the mixer unit stabilization process. These radionuclides were then analyzed individually for radiation dose to a worker.

The results of the bounding analysis are that if direct radiation is reduced by an equivalent of approximately 1.5 in. of iron, then the continuous occupancy requirement of 0.25 mrem/hr can be met. Also, if fugitive dust is reduced to less than 1,500 $\mu\text{g}/\text{m}^3$, then the continuous occupancy requirement of 0.25 mrem/hr can be met. Continuous occupancy was used in the bounding analysis to determine the risk to workers from the worst case. In actual operations the results could be adjusted by actual time workers are exposed to radiation.

A bounding loose surface contamination analysis was performed. Details are in Section 7. The results are that if fugitive dust on surfaces can be kept below 0.07 mg/100 cm², then the contamination limits will not be exceeded. Radiological confinement and control will be primarily for loose surface and airborne radioactivity control. This will be accomplished with confinement based on ventilation with air flowing under slightly negative air pressure and exhausted through high-efficiency particulate air (HEPA) filters. During stabilization process operation and decontamination activities, doors will need to be closed as much as possible to maintain confinement and correct ventilation flow direction. In the event of loss of power or failure of the ventilation system, the process may need to be shut down.

The as-low-as-reasonably-achievable (ALARA) evaluation of the SSSTF design consists of this review (including the calculations and analysis) and completed Form 431.01, "Radiological Control Design Review and Analysis Data." The management control procedure (MCP) "ALARA Program and Implementation," MCP-91, Sections 4.4.2 and 4.4.3, requires the process that this form outlines during the design of new facilities. The completed form is given in Appendix B. When the vendor designs, fabricates, and installs the mixing unit that will be used to stabilize waste, BBWI personnel will need to perform an ALARA evaluation during the reviews.

Because of radiological control issues, the SSSTF stabilization treatment area will require controlled access. Sub-areas within the decontamination building will need to be designated as Radiation Areas, Contamination Areas, High Contamination Areas, and/or Airborne Radioactivity Areas as conditions warrant. Inside the mixing unit, containment would probably be a combination of Radiation Area or High Contamination Area and Airborne Radioactivity Area. Areas within the stabilization area where boxes of soil or soil/debris are stored or in transit and the area around the soil/debris treatment process will probably be a Radiation Area. With a fully functional ventilation system, including HEPA filters, as required by the SSSTF design and good housekeeping, the area outside the mixing unit containment, but still within the stabilization area, may need to be a radiological buffer area.

The evaluation of radiological control instrumentation is in Section 8. Continuous air monitors (CAMs) and a personnel contamination monitor (PCM) are RadCon instruments that will be needed for the stabilization building. Radiological control technicians (RCTs) using portable survey instruments will be needed to assess the adequacy of radiological controls. Also, a proportional counter will be needed to analyze the radioactivity on smears taken during routine surveys. Portable air samplers will also be needed for spot sampling. For CAM location placement, air flow studies and hazard index determination will need to be performed prior to operation of the decontamination facility.

Final characterization in conjunction with shipping criteria may require an incoming radiation survey. Samples of the effluent water will need to be assessed for the amount of radioactivity present. Major sources of this water will be the stabilizing treatment area and the decontamination area, both within the decontamination facility.

Hands-on maintenance will only be performed after radiological conditions are assessed and decontamination, if required, has been performed. For maintenance activities, the use of appropriate personal protective equipment (PPE) (including respirators, controlled air breathing, etc.) may be required. Maintenance activities will adhere to the ALARA principles. Soils stabilization process equipment shall be capable of decontamination.

3. WORST-CASE COMPOSITE WASTE STREAM EXTERNAL RADIATION EXPOSURE RATE BOUNDING ANALYSIS

The highest external radiation exposure rate from any of the designated waste (see EDF-ER-264) to travel through the SSSTF was determined. The source term was determined by evaluating all of the waste streams and coming up with a composite waste stream that envelopes all the other waste streams. There are two different databases that give specific radionuclides and corresponding specific activity (pCi/g) values. The CERCLA Waste Inventory Database (CWID) (DOE-ID 2000) contains results of actual samples and analysis. The CWID data consists of radionuclide activity decayed to January 1, 2002. Only specific activity equal to or greater than 1E-3 pCi/g was used. Values below this are "considered to be no longer present as the activity is below practicable detection limits." (DOE-ID 2000, page 5-2)

The other database (EDF-ER-264) comprises calculated values based on original process streams when nuclear fuel was processed at the Idaho Nuclear Technology and Engineering Center (INTEC) (formerly the Idaho Chemical Processing Plant [ICPP]). The EDF-ER-264 data consists of radionuclide activity decayed to January 1, 2002. Table 3-1 lists the radionuclides and corresponding specific activity in the two databases. For radiological control bounding analysis purposes, the largest specific activity per radionuclide was used. Nuclides with specific activity less than 1E-3 pCi/g were deleted (see above). In the composite waste stream, the specific activity is higher in the CWID for the radionuclides, K-40, Co-57, Cs-137, Ce-144, Th-232, U-238, and Np-237.

The largest amount of contaminated soil to move through the SSSTF is in a 15 yd³ dump truck. From the volume of soil in the truck and the specific activity of the radionuclide the total activity for each specific radionuclide was determined. The details of the calculations and assumptions are in Table 3-1 and in the footnotes to the table. The density of soil used is 1.5 g/cm³ (DOE-ID 1994).

The external radiation exposure rate from the soil in the dump truck was analyzed. For each specific radionuclide, the highest specific activity was determined. These values were input into the MicroShield computer code (Grove Engineering 1999). The details of the calculations are in Table 3-1. The exposure rates at various distances from the soil were calculated. Table 3-2 shows the results. Appendix C contains the computer code analysis using MicroShield (Grove Engineering 1999).

To envelope the case of loaded dump trucks staged in a holding queue, multiply the exposure rates in Table 3-2 by the number of trucks. These exposure rates are for personnel located external to the truck.

A 5 mR/hr exposure rate at the location of the driver (located 3 ft from the edge of the dump truck load) was arbitrarily used. Five mR/hr exposure rate is the limit where a RadCon ribbon barrier is required to mark the boundary of a Radiation Area. Using 5 mR/hr is for scoping purposes only; actual design needs to consider ALARA. The driver is limited to an administrative control level of 700 mrem total effective dose equivalent (TEDE) per year from any occupational radiation source.^a

$$[(700 \text{ mrem}) / (5 \text{ mR/hr})] * [(1 \text{ mR/hr}) / (1 \text{ mrem/hr})] = 140 \text{ hours}$$

If the only occupational radiation the driver is exposed to in a year is from the bounding worst-case composite waste stream, then the driver could be in that radiation field for a maximum of 140 hr. The thickness of iron required to reduce the exposure rate to 5 mR/hr was determined. The details of the calculations and assumptions are in Table 3-1 and its associated footnotes. Table 3-3 shows the results;

a. Singer, A. N., Letter to Distribution, August 15, 2000, "INEEL Radiological Administration Control Limit."

4 in. of iron are needed to reduce the exposure rate to 5 mR/hr. Appendix D contains the computer code analysis using MicroShield (Grove Engineering 1999).

The shielding material is assumed to be tightly fitting around the outside of the soil. The exposure rate results for a specific thickness of shield that is tightly fitting next to the cuboid of contaminated soil would conservatively apply to the same configuration with a void between the soil and the shield. In all cases, the shielding configuration are cuboid / rectangular shields.

Table 3-1. Waste streams enveloping evaluation for external exposure rate bounding analysis.

Radionuclide	Database					
	CWID		EDF-ER-264		Worst-Case Specific Activity (pCi/g)	Activity in 8 × 14 × 3.5-ft Dump Truck (Ci)
	Waste Stream	pCi/g	Waste Stream	pCi/g		
H-3	CPP-67	3.40E-01	TF CPP-28 IDW	2.2E+03	2.2E+03	3.665E-02
C-14	—	—	CPP-28	2.1E-03	2.1E-03	3.499E-08
K-40	CPP-36/91	3.370E+01	CPP-36/91	2.7E+01	3.370E+01	5.614E-04
Co-57	CPP-1/4/5	0.358	CPP-1/4/5	3.6E-01	0.358	5.964E-06
Co-60	CPP-19	1.864E+04	CPP-19	1.9E+04	1.9E+04	3.165E-01
Zn-65	—	—	BORAX-1	1.0E-07	1.0E-07	1.666E-12
Se-79	—	—	CPP-28	7.5E+00	7.5E+00	1.250E-04
Kr-85	—	—	CPP-28	5.3E+04	5.3E+04	8.830E-01
Sr-90	CPP-19	1.216E+05	CPP-28	1.0E+06	1.0E+06	1.666E+01
Y-90	—	—	CPP-28	1.0E+06	1.0E+06	Microshield calculates Y-90 from Sr-90
Zr-93	—	—	CPP-28	3.9E+01	3.9E+01	1.666E+01
Nb-93m	—	—	CPP-28	6.1E-01	6.1E-01	1.016E-05
Tc-99	CPP-36/91	5.400E+01	CPP-28	2.6E+02	2.6E+02	4.332E-03
Rh-102 ^a	—	—	CPP-28	1.4E-03	1.4E-03	—
Rh-106	—	—	CPP-28	5.2E-01	5.2E-01	8.663E-06
Ru-106	CPP-67	6.E-03	CPP-28	5.2E-01	5.2E-01	8.663E-06
Pd-107	—	—	CPP-28	2.8E-01	2.8E-01	4.665E-06
Ag-108m	ARA-12	64.16	ARA-12	2.8E+01	64.16	1.069E-03
Cd-113m	—	—	CPP-28	7.4E+01	7.4E+01	1.233E-03
Sn-121m ^a	—	—	CPP-28	1.2E+00	1.2E+00	—
Sb-125	CPP-92	2.07	CPP-28	4.2E+02	4.2E+02	6.997E-03
Te-125m	—	—	CPP-28	1.0E+02	1.0E+02	1.666E-03
Sn-126	—	—	CPP-28	6.7E+00	6.7E+00	1.116E-04
Sb-126	—	—	CPP-28	9.4E-01	9.4E-01	1.566E-05
Sb-126m	—	—	CPP-28	6.7E+00	6.7E+00	1.116E-04
I-129	CPP-67	3.70E+00	CPP-67	3.7E+00	3.7E+00	6.164E-05

Table 3-1. (continued.)

Radionuclide	Database					
	CWID		EDF-ER-264		Worst-Case Specific Activity (pCi/g)	Activity in 8 × 14 × 3.5-ft Dump Truck (Ci)
	Waste Stream	pCi/g	Waste Stream	pCi/g		
Cs-134	CPP-1/4/5	994	CPP-1/4/5	9.9E+02	994	1.656E-02
Cs-135	—	—	CPP-28	1.6E+00	1.6E+00	2.666E-05
Cs-137	CPP-36/91	4.112E+06	CPP-28	1.1E+06	4.112E+06	6.851E+01
Ba-137m	—	—	CPP-28	1.1E+06	1.1E+06	Microshield calculates Ba-137m from Cs-137
Ce-144	CPP-1/4/5	880	CPP-28	8.0E-02	880	1.466E-02
Pr-144	—	—	CPP-28	8.0E-02	8.0E-02	1.333E-06
Pr-144m	—	—	CPP-28	1.2E-03	1.2E-03	1.999E-08
Pm-146	—	—	CPP-28	2.6E-01	2.6E-01	4.332E-06
Pm-147	—	—	CPP-28	1.7E+04	1.7E+04	2.832E-01
Sm-151	—	—	CPP-28	1.5E+04	1.5E+04	2.499E-01
Eu-152	CPP-19	8.273E+04	CPP-19	8.3E+04	8.3E+04	1.383E+00
Eu-154	CPP-19	4.897E+04	CPP-19	4.9E+04	4.9E+04	8.163E-01
Eu-155	CPP-19	8.224E+03	CPP-19	8.2E+03	8.224E+03	1.370E-01
Tl-208	—	—	CPP-28	9.0E-03	9.0E-03	1.499E-07
Pb-209	—	—	CPP-28	2.2E-06	2.2E-06	3.665E-11
Pb-212	—	—	CPP-28	2.5E-02	2.5E-02	4.165E-07
Bi-212	—	—	CPP-28	2.5E-02	2.5E-02	4.165E-07
Po-212	—	—	CPP-28	1.5E-02	1.5E-02	2.499E-07
Po-216	—	—	CPP-28	2.5E-02	2.5E-02	4.165E-07
Rn-220	—	—	CPP-28	2.5E-02	2.5E-02	4.165E-07
Ra-224	—	—	CPP-28	2.5E-02	2.5E-02	4.165E-07
Ra-226	ARA-25	44.54	ARA-25	4.5E+01	4.5E+01	7.497E-04
Th-228	ARA-23	0.287	ARA-23	2.9E-01	2.9E-01	4.831E-06
Th-230	ARA-23	1.53	ARA-23	1.5E+00	3.50E+00	5.831E-05
Th-230/U-234	BORAX-8	3.50E+00	—	—	NA	NA
Th-231	—	—	CPP-28	7.3E+00	7.3E+00	1.216E-04
Th-232	BORAX-8	2.12	BORAX-8	1.5E+00	2.12	3.532E-05
Th-234	—	—	CPP-28	7.8E-02	7.8E-02	1.299E-06
Pa-231	—	—	CPP-28	3.2E-03	3.2E-03	5.331E-08
Pa-233	—	—	CPP-28	2.0E+00	2.0E+00	3.332E-05
Pa-234m	—	—	CPP-28	7.8E-02	7.8E-02	1.299E-06
U-232	—	—	CPP-28	2.4E-02	2.4E-02	3.998E-07

Table 3-1. (continued.)

Radionuclide	Database					
	CWID		EDF-ER-264		Worst-Case Specific Activity (pCi/g)	Activity in 8 × 14 × 3.5-ft Dump Truck (Ci)
	Waste Stream	pCi/g	Waste Stream	pCi/g		
U-233	—	—	CPP-28	1.2E-03	1.04	1.733E-05
U-233/234	CFA-4	1.04	—	—	NA	NA
U-234	CFA-4	2.260E+01	CPP-28	2.7E+02	2.7E+02	4.498E-03
Th-230/U-234	BORAX-8	3.50E+00	—	—	NA	NA
U-235	ARA-25	2.72	CPP-28	7.3E+00	7.3	1.216E-04
U-235/236	CPP-67	1.00E-01	—	—	NA	NA
U-236	—	—	CPP-28	9.2E+00	9.2	1.533E-04
U-238	CPP-14	5.210E+01	CPP-14	2.2E+01	5.210E+01	8.680E-04
Np-237	CPP-14	5.50E+00	CPP-14	3.2E+00	5.50E+00	9.163E-05
Np-239	—	—	CPP-28	1.5E-02	1.5E-02	2.499E-07
Pu-238	CPP-36/91	7.607E+03	CPP-36/91	7.6E+03	7.607E+03	1.267E-01
Pu-239	ARA-1	5.33E-01	CPP-28	3.0E+02	324	5.398E-03
Pu-239/240	CPP-36/91	324	—	—	NA	NA
Pu-240	—	—	CPP-28	6.8E+01	324	5.398E-03
Pu-241	—	—	CPP-28	2.9E+03	2.90E+03	4.831E-02
Pu-242	—	—	CPP-28	1.1E-02	1.10E-02	1.833E-07
Am-241	CPP-92	23.32	CPP-36/91	7.5E+02	7.5E+02	1.250E-2
Am-242m	—	—	CPP-28	2.1E-03	2.10E-03	3.499E-08
Am-242	—	—	CPP-28	2.1E-03	2.10E-03	3.499E-08
Am-243	—	—	CPP-28	1.5E-02	1.50E-02	2.499E-07
Cm-244	—	—	CPP-28	8.2E-02	8.20E-02	1.366E-06
Pu-238/ Am-241	BORAX-8	0.036	—	—	NA	NA
Total	NA	NA	NA	NA	7.471E+06	NA

a. Rh-102 and Sm-121m are not in the MicroShield libraries. They were deleted because they are only about 2E-5% of the total activity.
 $[(1.4E-3 \text{ pCi/g} + 1.2 \text{ pCi/g}) / (7.5E6 \text{ pCi/g})] * 100 = 1.6E-5\%$

NOTES:

Converting pCi/g (soil) to Ci in a 15-yd³ dump truck:

Load size of a 15-yd³ dump truck; approximately 8 × 14 × 3.5 ft (C. O. Kingsford [kns@inel.gov] e-mail to A. D. Summers [ads@inel.gov], June 5, 2001)

Mass (g) of soil in a box:

$$\text{Soil density} = 1.5 \text{ g/cm}^3 \text{ (DOE-ID 1994)}$$

$$1 \text{ cm}^3 = 3.53E-5 \text{ ft}^3 \text{ (Shleien 1992, p. 47)}$$

$$1.5 \text{ g/cm}^3 \text{ (soil)} * 8 \text{ ft} * 14 \text{ ft} * 3.5 \text{ ft} * (3.53E-5 \text{ ft}^3) = 1.666E7 \text{ g soil}$$

$$\text{pCi/g (soil)} * 1.666E7 \text{ g (soil)} * (1E-12 \text{ Ci / pCi}) = 1.666E-5 \text{ Ci-g/pCi}$$

Multiply pCi/g (soil) by 1.666E-5 Ci-g/pCi to obtain Ci in a 15-yd³ dump truck.

Table 3-2. Exposure rate from dump truck containing the worst-case composite waste stream soil.
(0.25 in. Fe shield)

Distance from Truck	Exposure Rate (mR/hr)
30 cm (approximately 1 ft)	1.1E3
1 m (approximately 3 ft)	500
9 ft	140
15 ft	60
21 ft	33
27 ft	20
33 ft	14
39 ft	9.7
45 ft	7.3
51 ft	5.7
57 ft	4.5

Table 3-3. Exposure rate to dump truck driver from worst-case composite waste stream.

Fe Shield Thickness (in.)	Exposure Rate (mR/hr)
3.5	7.7
3.75	5.6
4	4.1

4. WORST-CASE COMPOSITE WASTE STREAM AIRBORNE RADIOACTIVITY BOUNDING ANALYSIS

Using the source term that was determined in Section 3, an internal dose bounding analysis was performed. The value of 0.25 mrem/hr is the dose rate that the *INEEL Radiological Control Manual*, Section 381 (Radiological Control Department 2000) recommends for design purposes of continuous occupied areas. Using this value, the limiting airborne dust concentration is calculated. Table 4-1 and its footnotes give the details of the calculations for the various cases of airborne dust concentration. Scoping analysis was used to narrow down to the value of $43 \mu\text{g}/\text{m}^3$.

This dust concentration is total dust and not just the respirable fraction. It is assumed that the radionuclides are homogeneously mixed with the soil. Also it is assumed all of the dust is comprised of 1 micron average median aerodynamic diameter (AMAD).

The dose conversion factors are from Environmental Protection Agency (EPA) (EPA 1988). The dose conversion factor gives the dose per intake of activity. To obtain the intake, the specific activity (pCi/g) of the individual radionuclide was converted to an air concentration ($\mu\text{Ci}/\text{cm}^3$). This was accomplished by multiplying the specific activity (pCi/g) by the airborne dust concentration ($\mu\text{g}/\text{m}^3$). The value that was obtained was then multiplied by the breathing rate (20 L/min) (ICRP 1975) of the worker during the 1-hr exposure time.

The results of the analysis are in Table 4-1 and its footnotes. The airborne dust concentration that results in 0.25 mrem internal dose in 1 hr of exposure was calculated to be $43 \mu\text{g}/\text{m}^3$.

Table 4-1. SSSTF enveloping waste stream internal radiation dose analysis--43 $\mu\text{g}/\text{m}^3$.

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) (10 CFR 835)	Air Concentration Worker is Immersed In ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
H-3 ^b	2.2E+03	H_2O vapor	2.E-05	9.460E-14	1.73E-11	7.27E-09
C-14	2.1E-03	—	1.E-06	9.030E-21	5.64E-10	2.26E-14
K-40	3.370E+01	D	2.E-07	1.449E-15	3.34E-09	2.15E-08
Co-57	0.358	Y	3.E-07	1.539E-17	2.45E-09	1.67E-10
Co-60	1.9E+04	Y	1.E-08	8.170E-13	5.91E-08	2.14E-04
Se-79	7.5E+00	W	2.E-07	3.225E-16	2.66E-09	3.81E-09
Kr-85 ^c	5.3E+04	NA	NA	NA	NA	NA
Sr-90	1.0E+06	Y	2.E-09	4.300E-11	3.51E-07	6.70E-02
Y-90	1.0E+06	Y	2.E-07	4.300E-11	2.28E-09	4.35E-04
Zr-93	3.9E+01	D	3.E-09	1.68E-15	8.67E-08	6.46E-07
Nb-93m	6.1E-01	Y	7.E-08	2.62E-17	7.90E-09	9.20E-10
Tc-99	2.6E+02	W	3.E-07	1.12E-14	2.25E-09	1.12E-07
Rh-102	1.40E-03	Y	2.E-08	6.02E-20	3.24E-08	8.66E-12
Rh-106 ^d	5.2E-01	D	1.E-05	2.24E-17	5.77E-11	5.73E-12
Ru-106	5.2E-01	Y	5.E-09	2.24E-17	1.29E-07	1.28E-08
Pd-107	2.8E-01	Y	2.E-07	1.20E-17	3.45E-09	1.84E-10
Ag-108m	64.16	Y	1.E-08	2.75E-15	7.66E-08	9.36E-07
Cd-113m	7.4E+01	D	1.E-09	3.18E-15	4.13E-07	5.83E-06
Sn-121m	1.2E+00	W	2.E-07	5.16E-17	3.11E-09	7.13E-10
Sb-125	4.2E+02	W	2.E-07	1.81E-14	3.30E-09	2.65E-07
Te-125m	1.0E+02	W	2.00E-07	4.300E-15	1.97E-09	3.76E-08
Sn-126	6.7E+00	D	2.E-08	2.881E-16	2.69E-08	3.44E-08
Sb-126	9.4E-01	W	2.E-07	4.04E-17	3.17E-09	5.69E-10
Sb-126m	6.7E+00	D	8.E-05	2.88E-16	9.17E-12	1.17E-11
I-129	3.7E+00	D	4.E-09	1.59E-16	4.69E-08	3.31E-08
Cs-134	994	D	4.E-08	4.27E-14	1.25E-08	2.37E-06
Cs-135	1.6E+00	D	5.E-07	6.88E-17	1.23E-09	3.76E-10
Cs-137	4.112E+06	D	7.E-08	1.77E-10	8.63E-09	6.78E-03
Ba-137m ^e	1.1E+06	NA	NA	NA	NA	NA
Ce-144	880	Y	6.00E-09	3.784E-14	1.01E-07	1.697E-05
Pr-144	8.0E-02	Y	5.00E-05	3.440E-18	1.17E-11	1.787E-13
Pr-144m ^f	1.2E-03	—	—	—	—	—
Pm-146	2.6E-01	Y	2.00E-08	1.118E-17	3.96E-08	1.966E-09

Table 4-1. (continued).

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) (10 CFR 835)	Air Concentration Worker is Immersed In ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
Pm-147	1.7E+04	Y	6.00E-08	7.310E-13	1.06E-08	3.44E-05
Sm-151	1.5E+04	W	4.E-08	6.45E-13	8.10E-09	2.32E-05
Eu-152	8.3E+04	W	1.E-08	3.57E-12	5.97E-08	9.46E-04
Eu-154	4.9E+04	W	8.E-09	2.11E-12	7.73E-08	7.23E-04
Eu-155	8.224E+03	W	4.E-08	3.54E-13	1.12E-08	1.76E-05
Tl-208 ^f	9.0E-03	—	—	—	—	—
Pb-209	2.2E-06	D	2.E-05	9.46E-23	2.56E-11	1.08E-17
Pb-212	2.5E-02	D	1.E-08	1.08E-18	4.56E-08	2.18E-10
Bi-212	2.5E-02	D	1.E-07	1.08E-18	5.83E-09	2.78E-11
Po-212 ^f	1.5E-02	—	—	—	—	—
Po-216 ^f	2.5E-02	—	—	—	—	—
Rn-220 ^f	2.5E-02	—	—	—	—	—
Ra-224	2.5E-02	W	7.E-10	1.08E-18	8.53E-07	4.07E-09
Ra-226	4.5E+01	W	3.E-10	1.94E-15	2.32E-06	1.99E-05
Th-228	2.9E-01	Y	4.E-12	1.25E-17	9.23E-05	5.11E-06
Th-230	3.50E+00	W	3.E-12	1.51E-16	8.80E-05	5.88E-05
Th-230/U-234	3.50E+00	NA	NA	NA	NA	NA
Th-231	7.3E+00	Y	3.E-06	3.14E-16	2.37E-10	3.30E-10
Th-232	2.12	W	5.E-13	9.12E-17	4.43E-04	1.79E-04
Th-234	7.8E-02	Y	6.E-08	3.35E-18	9.47E-09	1.41E-10
Pa-231	3.2E-03	W	7.E-13	1.38E-19	3.47E-04	2.12E-07
Pa-233	2.0E+00	Y	2.E-07	8.60E-17	2.58E-09	9.85E-10
Pa-234m ^f	7.8E-02	—	—	—	—	—
U-232	2.4E-02	Y	3.E-12	1.03E-18	1.78E-04	8.16E-07
U-233	1.04	Y	2.E-11	4.47E-17	3.66E-05	7.27E-06
U-233/234	1.04	NA	NA	NA	NA	NA
U-234	2.7E+02	Y	2.E-11	1.16E-14	3.58E-05	1.85E-03
Th-230/U-234	3.50E+00	NA	NA	NA	NA	NA
U-235	7.3E+00	Y	2.E-11	3.14E-16	3.32E-05	4.63E-05
U-235/236	1.0E-01	NA	NA	NA	NA	NA
U-236	9.2E+00	Y	2.E-11	3.96E-16	3.39E-05	5.95E-05
U-238	5.210E+01	Y	2.E-11	2.24E-15	3.20E-05	3.18E-04
Np-237	5.50E+00	W	2.E-12	2.37E-16	1.46E-04	1.53E-04
Np-239	1.5E-02	W	1.E-06	6.45E-19	6.78E-10	1.94E-12
Pu-238	7.607E+03	W	3.E-12	3.27E-13	1.06E-04	1.54E-01

Table 4-1. (continued).

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) (10 CFR 835)	Air Concentration Worker is Immersed In ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
Pu-239	324	W	2.E-12	1.39E-14	1.16E-04	7.17E-03
Pu-239/240	324	NA	NA	NA	NA	NA
Pu-240	324	W	2.E-12	1.393E-14	1.16E-04	7.17E-03
Pu-241	2.9E+03	W	1.E-10	1.25E-13	2.23E-06	1.23E-03
Pu-242	1.1E-02	W	2.E-12	4.73E-19	1.11E-04	2.33E-07
Am-241	7.5E+02	W	2.E-12	3.23E-14	1.20E-04	1.72E-02
Am-242m	2.1E-03	W	2.E-12	9.03E-20	1.15E-04	4.61E-08
Am-242	2.1E-03	W	3.E-08	9.03E-20	1.58E-08	6.33E-12
Am-243	1.5E-02	W	2.E-12	6.45E-19	1.19E-04	3.41E-07
Cm-244	8.2E-02	W	4.E-12	3.53E-18	6.70E-05	1.05E-06
Total	7.472E+06	NA	NA	NA	NA	2.53E-01

a. CEDE – Committed effective dose equivalent.

b. Derived air concentrations (DACS) and dose conversion factors are for H-3 vapor. No class.

c. Kr-85 is a noble gas. No internal dose. Minor external dose from submersion.

d. No class, DAC, or dose conversion factor for Rh-106. Class, DAC, and dose conversion factor for Rh-106m used.

e. Ba-137m is included in the Cs-137 DAC and dose conversion factor.

f. Pr-144m Tl-208, Po-212, Po-216, Rn-220, and Pa-234m are not in FGR 11, ICRP 30, or ICRP-60. They were deleted because they are only about 2E-6% of the total activity.

$$[(1.2E-3 \text{ pCi/g} + 9.0E-3 \text{ pCi/g} + 1.5E-2 \text{ pCi/g} + 2.5E-2 \text{ pCi/g} + 2.5E-2 \text{ pCi/g} + 7.8E-2 \text{ pCi/g}) / (7.5E6 \text{ pCi/g})] * 100 = 2E-6$$

NOTES:Converting pCi/g (soil) to $\mu\text{Ci}/\text{cm}^3$ (airborne dust) $\text{pCi/g (soil)} * \text{airborne dust concentration} * 1E-12 \text{ Ci/pCi} * \mu\text{Ci}/1E-6 \text{ Ci} \Rightarrow \mu\text{Ci}/\text{cm}^3 \text{ (airborne dust)}$ $\text{pCi/g (soil)} * [43 \mu\text{g} / \text{m}^3] * [1E-6 \text{ g} / \mu\text{g}] * [1E-2 \text{ m} / \text{cm}]^3 * [1E-12 \text{ Ci} / \text{pCi}] * [\mu\text{Ci} / 1E-6 \text{ Ci}] \Rightarrow \mu\text{Ci} / \text{cm}^3 \text{ (airborne dust)}$ $\text{pCi/g (soil)} * (4.300E-17 \text{ g} - \mu\text{Ci} / \text{pCi} - \text{cm}^3) \Rightarrow \mu\text{Ci}/\text{cm}^3 \text{ (airborne dust)}$ Internal Dose

Internal Radiation Dose = Radioactivity Inhaled During Exposure Time (Intake) * Dose Conversion Factor

Radioactivity Inhaled During Exposure Time (Bq) = Actual Airborne Concentration ($\mu\text{Ci}/\text{cm}^3$) * Volume of Air Breathed in During Exposure Time (cm^3)Example

Pu-238

Actual Airborne Concentration = $7.600E3 \text{ pCi/g} * (4.300E-17 \text{ g} - \mu\text{Ci} / \text{pCi} - \text{cm}^3) = 3.268E-13 \mu\text{Ci}/\text{cm}^3$

Exposure Time = 1 hr

Effective Dose Conversation Factor (W) = $1.06E-4 \text{ Sv/Bq}$ (EPA 1988)

Standard Man (ICRP 1975, p. 346) Breathes 20L/min (Shleien 1992, p. 499)

Radioactivity Inhaled During Exposure Time (Bq) = $(3.268E-13 \mu\text{Ci}/\text{cm}^3) * (20 \text{ L}/\text{min}) * (\text{mL}/1E-3 \text{ L}) * (\text{cm}^3/\text{mL}) * (1E-6 \text{ Ci}/\mu\text{Ci}) * ((3.7E10 \text{ dis/sec})/\text{Ci}) * (\text{Bq}/(\text{dis/sec})) * 1 \text{ hr} * [60 \text{ min/hr}]$

Radioactivity Inhaled During Exposure Time (Bq) = $(3.268E-13 \mu\text{Ci}/\text{cm}^3) * (4.440E10 \text{ Bq}\cdot\text{cm}^3/\mu\text{Ci}) = 1.451E-2 \text{ Bq}$

Radioactivity Inhaled During Exposure Time of One Hour = $1.451E-2 \text{ Bq}$

Effective Dose (rem) = $1.451E-2 \text{ Bq} * 1.06E-4 \text{ Sv/Bq} * 100 \text{ rem/Sv} * [\text{mrem}/1E-3 \text{ rem}] = 0.1538 \text{ mrem}$

During Exposure Time of 1 hr $\Rightarrow 0.1538 \text{ mrem}$

Effective Dose (rem) = $(3.268E-13 \mu\text{Ci}/\text{cm}^3) * (1.06E-4 \text{ Sv/Bq}) * (4.440E10 \text{ Bq}\cdot\text{cm}^3/\mu\text{Ci}) * (100 \text{ rem/Sv}) * [\text{mrem}/1E-3 \text{ rem}]$

Effective Dose (rem) = $(3.268E-13 \mu\text{Ci}/\text{cm}^3) * (1.06E-4 \text{ Sv/Bq}) * 4.440E15 \text{ Bq}\cdot\text{cm}^3 \cdot \text{mrem/Sv} \cdot \mu\text{Ci} \cdot \text{hr} = 0.1538 \text{ mrem}$

5. TREATMENT/STABILIZATION EXTERNAL RADIATION EXPOSURE RATE BOUNDING ANALYSIS

The bounding external radiation exposure rate for the treatment/stabilization process was analyzed using boxes containing CPP-92, CPP-98, and CPP-99 waste streams. The source term was determined by evaluating the three waste streams, CPP-92, CPP-98, and CPP-99. There are two different databases that give specific radionuclides and corresponding specific activity (pCi/g) values. The CWID database (DOE-ID 2000) contains results of actual samples and analysis. The CWID data consists of radionuclides activity decayed to January 1, 2002. Only specific activities equal to or greater than 1E-3 pCi/g were used. Values below this are "considered to be no longer present as the activity is below practicable detectable limits" (DOE-ID 2000, page 5-2). Only the CPP-92 waste stream is in the CWID database because it was the only one of the three waste streams that was sampled.

The other database (EDF-ER-264) comprises calculated values based on original process streams when nuclear fuel was processed at INTEC. The EDF-ER-264 data consists of radionuclide activity decayed to January 1, 2002. The radionuclides and the corresponding specific activities in the two databases are presented in Table 5-1. For radiological control bounding analysis purposes, the largest specific activity per radionuclide was used. Nuclides with specific activity less than 1E-3 pCi/g were deleted (see above). As is shown in Table 5-1, for every radionuclide the highest specific activity is for the CPP-92 waste stream. In the CPP-92 waste stream, the specific activity is higher in the CWID database for the radionuclides, U-234, Pu-238, Pu-239/240, and Am-241.

The external radiation exposure rate from the contaminated soil was analyzed. For each specific radionuclide, the highest specific activity was determined. Then the total activity for each specific radionuclide in the volume of soil in a $4 \times 4 \times 8$ -ft box was determined. These values were input into the MicroShield computer code (Grove Engineering 1999). The density of soil used was 1.5 g/cm^3 (DOE-ID 1994). The details of the calculations are in Table 5-1 and its footnotes. The exposure rates at various distances from the soil were calculated. Table 5-2 shows the results. Appendix C contains the computer code analysis using MicroShield (Grove Engineering 1999).

Another analysis consisted of varying the thickness of iron. For the CPP-92 waste stream, when the iron was 1.7-in. thick, the direct radiation was reduced to 0.25 mrem in 1 hr at 30 cm from the outside of the shield (see Figure 5-1). Table 5-3 shows the results. Appendix D contains the computer code MicroShield analysis for this thickness of iron (Grove Engineering 1999).

In the shielding analysis, all exposure rate results were calculated starting at 30 cm from the outside of the shielding material. The shielding material is assumed to be tightly fitting around the outside of the soil. The exposure rate results, for a specific thickness of shielding that is tightly fitting around the cuboid, would conservatively apply to the same configuration with a void between the soil and the shield. In all cases, the shielding configuration are cuboid / rectangular shields.

The determination of the 1.2-in.-thick iron was not for design purposes, but to assist in assessing how much shielding is needed to reduce the radiation risk. The continuous occupancy is conservative because it assumes a worker is standing next to the mixer for 40 hr per week for 1 year. Actual design will need to include actual occupancy.

Table 5-1. CPP-92, CPP-98, and CPP-99 waste streams evaluation for external exposure rate bounding analysis.

Radionuclide	CPP-92		CPP-98/99		Worst-Case Specific Activity (pCi/g)	Activity in 4 × 4 × 8-ft Box (Ci)
	CWID (pCi/g)	EDF-ER-264 (pCi/g)	EDF-ER-264 (pCi/g)			
H-3	—	6.4E+00	1.4E-01	6.4E+00	6.4E+00	3.481E-05
Co-60	1.49E+00	1.5E+00	—	1.5E+00	1.5E+00	8.159E-06
Se-79	—	2.1E-02	4.5E-04	2.1E-02	2.1E-02	1.142E-07
Kr-85	—	1.5E+02	3.2E+00	1.5E+02	1.5E+02	7.833E-04
Sr-90	9.040E+03	2.9E+03	6.3E+01	9.040E+03	9.040E+03	4.917E-02
Y-90	—	2.9E+03	6.3E+01	2.9E+03	2.9E+03	1.577E-02
Zr-93	—	1.1E-01	2.3E-03	1.1E-01	1.1E-01	5.983E-07
Nb-93m	—	1.7E-03	—	1.7E-03	1.7E-03	9.246E-09
Tc-99	—	7.4E-01	1.6E-02	7.4E-01	7.4E-01	4.025E-06
Rh-106	—	1.5E-03	—	1.5E-03	1.5E-03	8.159E-09
Ru-106	—	1.5E-03	—	1.5E-03	1.5E-03	8.159E-09
Cd-113m	—	2.1E-01	4.4E-03	2.1E-01	2.1E-01	1.142E-06
Sn-121m	—	3.5E-03	—	3.5E-03	3.5E-03	1.904E-08
Sb-125	2.07	2.1E+00	2.5E-02	2.1E+00	2.1E+00	1.142E-05
Te-125m	—	2.9E-01	6.2E-03	2.9E-01	2.9E-01	1.577E-06
Sn-126	—	1.9E-02	—	1.9E-02	1.9E-02	1.033E-07
Sb-126	—	2.7E-03	—	2.7E-03	2.7E-03	1.469E-08
Sb-126m	—	1.9E-02	—	1.9E-02	1.9E-02	1.033E-07
I-129	3.10E+00	3.1E+00	—	3.1E+00	3.1E+00	1.686E-05
Cs-134	0.195	2.0E-01	7.0E-03	2.0E-01	2.0E-01	1.088E-06
Cs-135	—	4.6E-03	9.8E-05	4.6E-03	4.6E-03	2.502E-08
Cs-137	6.530E+03	3.1E+03	6.7E+01	6.530E+03	6.530E+03	3.552E-02
Ba-137m	—	3.0E+03	6.3E+01	3.0E+03	3.0E+03	1.632E-02
Pm-147	—	4.9E+01	1.0E+00	4.9E+01	4.9E+01	2.665E-04
Sm-151	—	4.3E+01	9.3E-01	4.3E+01	4.3E+01	2.339E-04
Eu-152	—	1.7E-02	3.6E-04	1.7E-02	1.7E-02	9.246E-08
Eu-154	—	7.9E+00	1.7E-01	7.9E+00	7.9E+00	4.297E-05
Eu-155	—	4.8E+00	1.0E-01	4.8E+00	4.8E+00	2.611E-05
Th-231	—	2.1E-02	4.4E-04	2.1E-02	2.1E-02	1.142E-07
Pa-233	—	5.6E-03	1.2E-04	5.6E-03	5.6E-03	3.046E-08
U-234	5.10E+00	7.8E-01	1.7E-02	5.10E+00	5.10E+00	2.774E-05
U-235	2.30E-01	2.3E-01	—	2.3E-01	2.3E-01	1.251E-06
U-236	—	2.6E-02	—	2.6E-02	2.6E-02	1.414E-07

Table 5-1. (continued).

Radionuclide	CPP-92		CPP-98/99		Worst-Case Specific Activity (pCi/g)	Activity in 4 × 4 × 8-ft Box (Ci)
	CWID (pCi/g)	EDF-ER-264 (pCi/g)	EDF-ER-264 (pCi/g)	—		
Np-237	1.50E-01	1.5E-01	—	—	1.5E-01	8.159E-07
Pu-238	244	1.1E+02	3.3E-02	244	244	1.327E-03
Pu-239	—	8.6E-01	1.8E-02	24.69	24.69	1.343E-04
Pu-239/240	24.69	NA	NA	NA	NA	NA
Pu-240	—	1.9E-01	4.1E-03	24.69	24.69	1.343E-04
Pu-241	—	8.2E+00	1.8E-01	8.2E+00	8.2E+00	4.460E-05
<u>Am-241</u>	<u>23.32</u>	<u>9.3E+00</u>	<u>1.2E-02</u>	<u>23.32</u>	<u>23.32</u>	<u>1.268E-04</u>

NOTES:

No CWID data for waste streams CPP-98 and CPP-99.

Converting pCi/g (soil) to Ci in a 4 × 4 × 8-ft box.

Mass (g) of soil in a box:

Soil density = 1.5 g/cm³ (DOE-ID 1994)).

1 cm³ = 3.53E-05 ft³ (Shleien 1992, p. 47).

1.5 g/cm³ (soil) * 4 ft * 4 ft * 8 ft * (cm³/3.53E-05 ft³) = 5.439E6 g soil.

pCi/g (soil) * 5.439E6 g (soil) * (1E-12 Ci/pCi) = 5.439E-06 Ci-g/pCi.

Multiply pCi/g (soil) by 5.439E-06 Ci-g/pCi to obtain Ci in a 4 × 4 × 8-ft box.

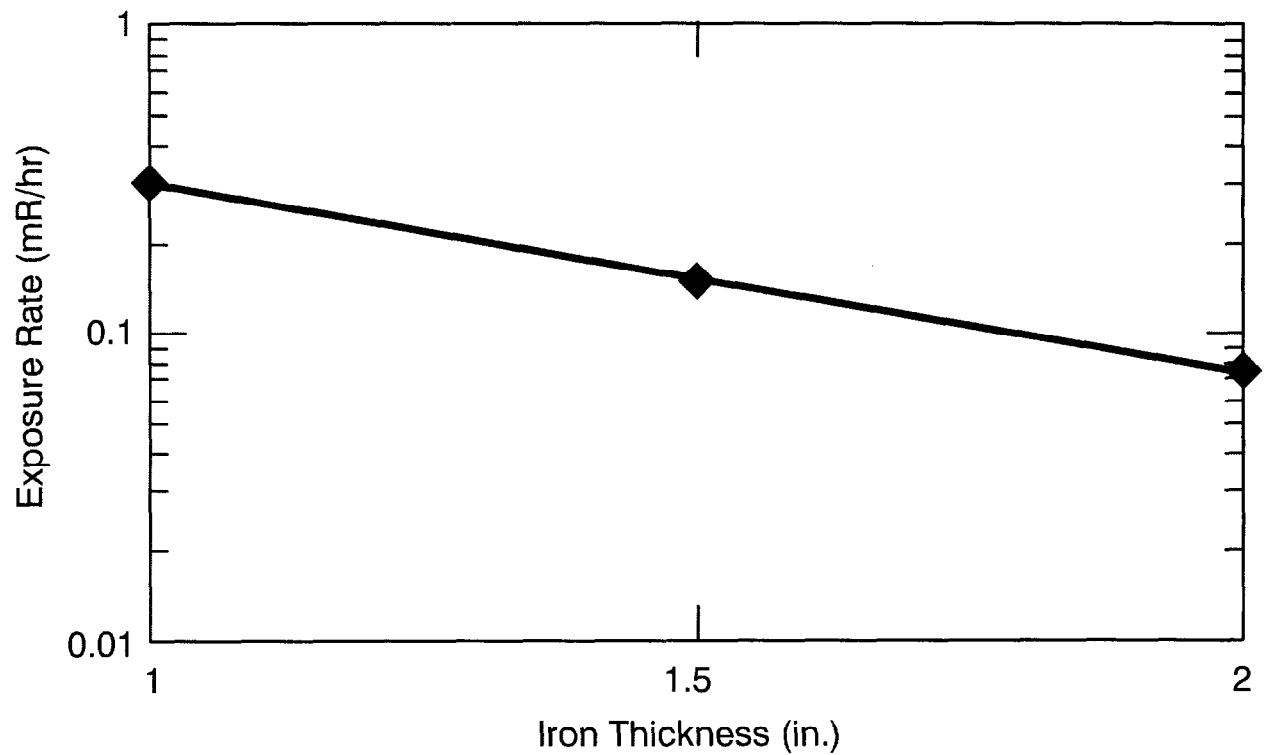
Table 5-2. Exposure rate from unshielded box containing CPP-92 waste stream soil.

Distance from Box	Exposure Rate (mR/hr)
0.98 ft (30 cm)	1.1
3 ft	0.45
6 ft	0.18
9 ft	0.089

Table 5-3. CPP-92 waste stream soil box exposure rate at 30 cm from various thicknesses of iron.

Iron Thickness (in)	Exposure Rate (mR/hr)
1	0.30
1.2	0.25 ^a
1.5	0.15
2	0.077

a. Determined from the plot of the calculated values in Figure 5-1.



01-GA50820-02

Figure 5-1. CPP-92 waste stream soil box exposure rate at 30 cm from various thickness of iron.

6. TREATMENT/STABILIZATION AIRBORNE RADIOACTIVITY BOUNDING ANALYSIS

The potential largest amount of airborne radioactivity for the treatment/stabilization process will be generated by the mixer unit. The value of 0.25 mrem/hr is the dose rate that the *INEEL Radiological Control Manual*, Section 381, (Radiological Control Department 2000) recommends for design purposes of continuous occupied areas. Using this value, the limiting airborne dust concentration is calculated. The source term is waste stream CPP-92, which is considered the worst case. Table 5-1 lists the details of the three waste streams for CPP-92, CPP-98, and CPP-99 and shows that CPP-92 is the worst case. Tables 6-1, 6-2, and 6-3 give the details of the calculations for the various cases of airborne dust concentration. The footnotes to Tables 6-1, 6-2, and 6-3 give the assumptions and the calculational methodology. This dust concentration is total dust and not just the respirable fraction. It is assumed the radionuclides are homogeneously mixed with the soil. Also, it is assumed all of the dust is comprised of 1 micron activity median aerodynamic diameter (AMAD).

The dose conversion factors are from EPA (1988). The dose conversion factor gives the dose per intake of activity. To obtain the intake, the specific activity (pCi/g) of the individual radionuclide was converted to an air concentration ($\mu\text{Ci}/\text{cm}^3$). This was accomplished by multiplying the specific activity (pCi/g) by the airborne dust concentration ($\mu\text{g}/\text{m}^3$). The value that was obtained was then multiplied by the breathing rate (20 L/min) (ICRP 1975) of the worker during the 1-hr exposure time.

The results of the analysis are in Table 6-4 and Figure 6-1. The airborne dust concentration that results in 0.25 mrem internal dose in 1 hr of exposure was calculated to be $1500 \mu\text{g}/\text{m}^3$. This bounding analysis result gives the minimum amount of fugitive dust that provides a basis for the need for possible separate containment and ventilation for the mixer unit.

Based on the following, the radiological value for the worst case from the calculational model will be the limiting value in comparisons to industrial hygiene limits. The American Conference of Governmental Industrial Hygienists (ACGIH) (ACGIH 1999) established exposure limits for nuisance particulate (dust) at $10.0 \text{ mg}/\text{m}^3$ in addition to a respirable particulate limit of $3.0 \text{ mg}/\text{m}^3$. Both of these values are threshold limit values (TLVs) and represent particulate containing no asbestos and <1% crystalline silica. These limits are based upon a conventional 8 hr work day, and a 40 hr workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. In spite of the fact that serious adverse health effects are not believed likely as a result of exposure up to the TLV concentrations, the best practice is to maintain concentrations of atmospheric contaminants as low as practical. The value $1500 \mu\text{g}/\text{m}^3$ is less than $100 \text{ mg}/\text{m}^3$ and therefore is the limiting value.

Table 6-1. Calculation and results for 1,400 $\mu\text{g}/\text{m}^3$ airborne dust concentration.

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) (10 CFR 835)	Air Concentration Worker is Immersed In ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
H-3 ^b	6.4E+00		2.E-05	8.960E-15	1.73E-11	6.88E-10
Co-60	1.5E+00	Y	1.E-08	2.100E-15	5.91E-08	5.51E-07
Se-79	2.1E-02	W	2.E-07	2.940E-17	2.66E-09	3.47E-10
Kr-85 ^c	1.5E+02	NA	NA	NA	NA	NA
Sr-90	9.040E+03	Y	2.E-09	1.266E-11	3.51E-07	1.97E-02
Y-90	2.9E+03	Y	2.E-07	4.060E-12	2.28E-09	4.11E-05
Zr-93	1.1E-01	D	3.E-09	1.54E-16	8.67E-08	5.93E-08
Nb-93m	1.7E-03	Y	7.E-08	3.40E-18	7.90E-09	1.19E-10
Tc-99	7.4E-01	W	3.E-07	1.04E-15	2.25E-09	1.03E-08
Rh-106 ^d	1.5E-03	D	1.E-05	2.10E-18	5.77E-11	5.38E-13
Ru-106	1.5E-03	Y	5.E-09	2.10E-18	1.29E-07	1.20E-09
Cd-113m	2.1E-01	D	1.E-09	2.94E-16	4.13E-07	5.39E-07
Sn-121m	3.5E-03	W	2.E-07	4.90E-18	3.11E-09	6.77E-11
Sn-126	1.9E-02	W	2.E-08	2.66E-17	2.69E-08	3.18E-09
Sb-125	2.1E+00	W	2.E-07	2.94E-15	3.30E-09	4.31E-08
Sb-126	2.7E-03	W	2.E-07	3.78E-18	3.17E-09	5.32E-11
Sb-126m	1.9E-02	D	8.E-05	2.66E-17	9.17E-12	1.08E-12
Te-125m	2.9E-01	W	2.E-07	4.060E-16	1.97E-09	3.55E-09
I-129	3.1E+00	D	4.E-09	4.34E-15	4.69E-08	9.04E-07
Cs-134	2.0E-01	D	4.E-08	4.00E-16	1.25E-08	2.22E-08
Cs-135	4.6E-03	D	5.E-07	6.44E-18	1.23E-09	3.52E-11
Cs-137	6.530E+03	D	7.E-08	9.14E-12	8.63E-09	3.50E-04
Ba-137m ^e	3.0E+03	NA	NA	NA	NA	NA
Pm-147	4.9E+01	Y	6.E-08	6.860E-14	1.06E-08	2.123E-05
Sm-151	4.3E+01	W	4.E-08	6.02E-14	8.10E-09	2.17E-06
Eu-152	1.7E-02	W	1.E-08	2.38E-17	5.97E-08	6.31E-09
Eu-154	7.9E+00	W	8.E-09	1.11E-14	7.73E-08	3.80E-06
Eu-155	4.8E+00	W	4.E-08	6.72E-15	1.12E-08	3.34E-07
Th-231	2.1E-02	Y	3.E-06	2.94E-17	2.37E-10	3.09E-11
Pa-233	5.6E-03	Y	2.E-07	7.84E-18	2.58E-09	8.98E-11
U-234	5.10E+00	Y	2.E-11	1.02E-14	3.58E-05	1.62E-03
U-235	2.3E-01	Y	2.E-11	3.22E-16	3.32E-05	4.75E-05
U-236	2.6E-02	Y	2.E-11	5.20E-17	3.39E-05	7.83E-06

Table 6-1. (continued).

Radionuclide	Specific Activity (pCi/g)	Class	DAC (μCi/cm ³) (10 CFR 835)	Air Concentration Worker is Immersed In (μCi/cm ³)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
Np-237	1.5E-01	W	2.E-12	2.10E-16	1.46E-04	1.36E-04
Pu-238	2.44E+02	W	3.E-12	3.42E-13	1.06E-04	1.61E-01
Pu-239	24.69	W	2.E-12	3.46E-14	1.16E-04	1.78E-02
Pu-239/240	24.69	NA	NA	NA	NA	NA
Pu-240	24.69	W	2.E-12	3.458E-14	1.16E-04	1.78E-02
Pu-241	8.2E+00	W	1.E-10	1.15E-14	2.23E-06	1.14E-04
Am-241	2.332E+01	W	2.E-12	3.26E-14	1.20E-04	1.74E-02
Total	NA	NA	NA	NA	NA	0.236

a. CEDE – Committed effective dose equivalent.

b. DACs and dose conversion factors are for H-3 vapor. No class.

c. Kr-85 is a noble gas. No internal dose. Minor external dose from submersion.

d. No class, DAC, or dose conversion factor for Rh-106. Class, DAC, and dose conversion factor for Rh-106m used.

e. Ba-137m is included in the Cs-137 DAC and dose conversion factor.

NOTES:

Converting pCi/g(soil) To μCi/cm³ (airborne dust)

pCi/g(soil) * airborne dust concentration * 1E-12 Ci/pCi * μCi/1E-6 Ci => μCi/cm³ (airborne dust)

pCi/g(soil) * [1.4000E3 μg/m³] * [1E-6 g/μg] * (1E-2 m/cm)³ * [1E-12 Ci/pCi] * [μCi/1E-6 Ci] => μCi/cm³ (airborne dust)

pCi/g(soil) * (1.4000E-15 g – μCi/pCi – cm³) => μCi/cm³ (airborne dust)

Internal Dose

Internal Radiation Dose = Radioactivity Inhaled During Exposure Time (Intake) * Dose Conversion Factor

Radioactivity Inhaled During Exposure Time (Bq) = Actual Airborne Concentration (μCi/cm³) * Volume of Air Breathed in During Exposure Time (cm³)

Example

Pu-238

Actual Airborne Concentration = 244 pCi/g * (1.4000E-15 g – μCi/pCi – cm³) = 3.416E-13 μCi/cm³

Exposure Time = 1 hr

Effective Dose Conversion Factor (W) = 1.06E-4 Sv/Bq (EPA 1988)

Standard Man (ICRP 1975, p. 346) Breathes 20 L/min (Shleien 1992, p. 499)

Radioactivity Inhaled During Exposure Time (Bq) = (3.416E-13 μCi/cm³) * (20L/min) * mL/1E-3 L) * (cm³/mL) * (1E-6 Ci/μCi) * ((3.7E10 dis/sec)/Ci) * (Bq/(dis/sec)) * 1 hr * [60 min/hr]

Radioactivity Inhaled During Exposure Time (Bq) = (3.416E-13 μCi/cm³) * (4.440E10 Bq·cm³/μCi) = 0.01517 Bq

Radioactivity Inhaled During Exposure Time of One Hour = 0.01517 Bq

Effective Dose (rem) = 0.01517 Bq * 1.06E-4 Sv/Bq * 100 rem/Sv * [mrem/1E-3 rem] = 0.1608 mrem

During Exposure Time of 1 hr => 0.1608 mrem

Effective Dose (rem) = (3.416E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * (4.440E10 Bq·cm³/μCi) * (100 rem/Sv) * (mrem/1E-3 rem)

Effective Dose (rem) = (3.416E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * 4.440E15 Bq·cm³-mrem/Sv-μCi-hr) = 0.1608 mrem

Table 6-2. Calculation results for 1600 $\mu\text{g}/\text{m}^3$ airborne dust concentration.

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) (10 CFR 835)	Air Concentration Worker is Immersed In ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
H-3 ^b	6.4E+00		2.E-05	1.024E-14	1.73E-11	7.87E-10
Co-60	1.5E+00	Y	1.E-08	2.400E-15	5.91E-08	6.30E-07
Se-79	2.1E-02	W	2.E-07	3.360E-17	2.66E-09	3.97E-10
Kr-85 ^c	1.5E+02	NA	NA	NA	NA	NA
Sr-90	9.040E+03	Y	2.E-09	1.446E-11	3.51E-07	2.25E-02
Y-90	2.9E+03	Y	2.E-07	4.640E-12	2.28E-09	4.70E-05
Zr-93	1.1E-01	D	3.E-09	1.76E-16	8.67E-08	6.78E-08
Nb-93m	1.7E-03	Y	7.E-08	2.72E-18	7.90E-09	9.54E-11
Tc-99	7.4E-01	W	3.E-07	1.18E-15	2.25E-09	1.18E-08
Rh-106 ^d	1.5E-03	D	1.E-05	2.40E-18	5.77E-11	6.15E-13
Ru-106	1.5E-03	Y	5.E-09	2.40E-18	1.29E-07	1.37E-09
Cd-113m	2.1E-01	D	1.E-09	3.36E-16	4.13E-07	6.16E-07
Sn-121m	3.5E-03	W	2.E-07	5.60E-18	3.11E-09	7.73E-11
Sn-126	1.9E-02	W	2.E-08	3.040E-17	2.69E-08	3.63E-09
Sb-125	2.1E+00	W	2.E-07	3.36E-15	3.30E-09	4.92E-08
Sb-126	2.7E-03	W	2.E-07	4.32E-18	3.17E-09	6.08E-11
Sb-126m	1.9E-02	D	8.E-05	3.04E-17	9.17E-12	1.24E-12
Te-125m	2.9E-01	W	2.E-07	4.640E-16	1.97E-09	4.06E-09
I-129	3.1E+00	D	4.E-09	4.96E-15	4.69E-08	1.03E-06
Cs-134	2.0E-01	D	4.E-08	3.20E-16	1.25E-08	1.78E-08
Cs-135	4.6E-03	D	5.E-07	7.36E-18	1.23E-09	4.02E-11
Cs-137	6.530E+03	D	7.E-08	1.04E-11	8.63E-09	4.00E-04
Ba-137m ^e	3.0E+03	NA	NA	NA	NA	NA
Pm-147	4.9E+01	Y	6.E-08	7.840E-14	1.06E-08	2.426E-05
Sm-151	4.3E+01	W	4.E-08	6.88E-14	8.10E-09	2.47E-06
Eu-152	1.7E-02	W	1.E-08	2.72E-17	5.97E-08	7.21E-09
Eu-154	7.9E+00	W	8.E-09	1.26E-14	7.73E-08	4.34E-06
Eu-155	4.8E+00	W	4.E-08	7.68E-15	1.12E-08	3.82E-07
Th-231	2.1E-02	Y	3.E-06	3.36E-17	2.37E-10	3.54E-11
Pa-233	5.6E-03	Y	2.E-07	8.96E-18	2.58E-09	1.03E-10
U-234	5.10E+00	Y	2.E-11	8.16E-15	3.58E-05	1.30E-03
U-235	2.3E-01	Y	2.E-11	3.68E-16	3.32E-05	5.42E-05
U-236	2.6E-02	Y	2.E-11	4.16E-17	3.39E-05	6.26E-06

Table 6-2. (continue).

Radionuclide	Specific Activity (pCi/g)	Class	DAC (μCi/cm ³) (10 CFR 835)	Air Concentration Worker is Immersed In (μCi/cm ³)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
Np-237	1.5E-01	W	2.E-12	2.40E-16	1.46E-04	1.56E-04
Pu-238	2.44E+02	W	3.E-12	3.90E-13	1.06E-04	1.84E-01
Pu-239	24.69	W	2.E-12	3.95E-14	1.16E-04	2.04E-02
Pu-239/240	24.69	NA	NA	NA	NA	NA
Pu-240	24.69	W	2.E-12	3.952E-14	1.16E-04	2.04E-02
Pu-241	8.2E+00	W	1.E-10	1.31E-14	2.23E-06	1.30E-04
Am-241	2.332E+01	W	2.E-12	3.73E-14	1.20E-04	1.99E-02
Total		NA	NA	NA	NA	2.69E-01

a. CEDE – Committed effective dose equivalent.

b. DACs and dose conversion factors are for H-3 vapor. No class.

c. Kr-85 is a noble gas. No internal dose. Minor external dose from submersion.

d. No class, DAC, or dose conversion factor for Rh-106. Class, DAC, and dose conversion factor for Rh-106m used.

e. Ba-137m is included in the Cs-137 DAC and dose conversion factor.

NOTES:(Converting pCi/g[soil] To μCi/cm³ [airborne dust]) $p\text{Ci/g(soil)} * \text{airborne dust concentration} * 1\text{E-12 Ci/pCi} * \mu\text{Ci}/1\text{E-6 Ci} = >\mu\text{Ci}/\text{cm}^3 \text{ (airborne dust)}$ $p\text{Ci/g(soil)} * [1.600E3 \mu\text{g/m}^3] * [1\text{E-6 g/\mu g}] * (1\text{E-2 m/cm})^3 * [1\text{E-12 Ci/pCi}] * [\mu\text{Ci}/1\text{E-6 Ci}] = >\mu\text{Ci}/\text{cm}^3 \text{ (airborne dust)}$ $p\text{Ci/g(soil)} * (1.600E-15 g - \mu\text{Ci/pCi} - \text{cm}^3) = >\mu\text{Ci}/\text{cm}^3 \text{ (airborne dust)}$ Internal Dose

Internal Radiation Dose = Radioactivity Inhaled During Exposure Time (Intake) * Dose Conversion Factor

Radioactivity Inhaled During Exposure Time (Bq) = Actual Airborne Concentration (μCi/cm³) * Volume of Air Breathed in During Exposure Time (cm³)Example

Pu-238

Actual Airborne Concentration = 244 pCi/g * (1.600E-15 g - μCi/pCi - cm³) = 3.904E-13 μCi/cm³

Exposure Time = 1 hr

Effective Dose Conversion Factor (W) = 1.06E-4 Sv/Bq (EPA 1988)

Standard Man (ICRP 1975, p. 346) Breathes 20 L/min (Shleien 1992, p. 499)

Radioactivity Inhaled During Exposure Time (Bq) = (3.904E-13 μCi/cm³) * (20 L/min) * (mL/1E-3 L) * (cm³/mL) * (1E-6 Ci/μCi) * ((3.7E10 dis/sec/Ci) * (Bq/(dis/sec)) * 1 hr * [60 min/hr]Radioactivity Inhaled During Exposure Time (Bq) = (3.904E-13 μCi/cm³) * (4.440E10 Bq·cm³/μCi) = 1.733E-2 Bq

Radioactivity Inhaled During Exposure Time of One Hour = 1.733E-2 Bq

Effective Dose (rem) = 1.733E-2 Bq * 1.06E-4 Sv/Bq * 100 rem/Sv * [mrem/1E-3 rem] = 0.1837 mrem

During Exposure Time of 1 hr = >0.1837 mrem

Effective Dose (rem) = (3.904E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * (4.440E10 Bq·cm³/μCi) * (100 rem/Sv) * (mrem/1E-3 rem)Effective Dose (rem) = (3.904E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * 4.440E15 Bq·cm³-mrem/Sv-μCi-hr = 0.1837 mrem

Table 6-3. SSSTF Decon Building CPP-92 waste stream internal radiation dose analysis—2000 µg/m³.

Radionuclide	Specific Activity (pCi/g)	Class	DAC (µCi/cm ³) (10 CFR 835)	Air Concentration Worker is Immersed In (µCi/cm ³)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
H-3 ^b	6.4E+00		2.E-05	1.280E-14	1.73E-11	9.83E-10
Co-60	1.5E+00	Y	1.E-08	3.000E-15	5.91E-08	7.87E-07
Se-79	2.1E-02	W	2.E-07	4.200E-17	2.66E-09	4.96E-10
Kr-85 ^c	1.5E+02	NA	NA	NA	NA	NA
Sr-90	9.040E+03	Y	2.E-09	1.808E-11	3.51E-07	2.82E-02
Y-90	2.9E+03	Y	2.E-07	5.800E-12	2.28E-09	5.87E-05
Zr-93	0.11	D	3.E-09	2.20E-16	8.67E-08	8.47E-08
Nb-93m	1.7E-03	Y	7.E-08	3.40E-18	7.90E-09	1.19E-10
Tc-99	7.4E-01	W	3.E-07	1.48E-15	2.25E-09	1.48E-08
Rh-106 ^d	1.5E-03	D	1.E-05	3.00E-18	5.77E-11	7.69E-13
Ru-106	1.5E-03	Y	5.E-09	3.00E-18	1.29E-07	1.72E-09
Cd-113m	2.1E-01	D	1.E-09	4.20E-16	4.13E-07	7.70E-07
Sn-121m	3.5E-03	W	2.E-07	7.00E-18	3.11E-09	9.67E-11
Sn-126	1.9E-02	W	2.E-08	3.040E-17	2.69E-08	3.63E-09
Sb-125	2.1E+00	W	2.E-07	4.20E-15	3.30E-09	6.15E-08
Sb-126	2.7E-03	W	2.E-07	5.40E-18	3.17E-09	7.60E-11
Sb-126m	1.9E-02	D	8.E-05	3.80E-17	9.17E-12	1.55E-12
Te-125m	2.9E-01	W	2.E-07	5.800E-16	1.97E-09	5.07E-09
I-129	3.1E+00	D	4.E-09	6.20E-15	4.69E-08	1.29E-06
Cs-134	2.0E-01	D	4.E-08	4.00E-16	1.25E-08	2.22E-08
Cs-135	4.6E-03	D	5.E-07	9.20E-18	1.23E-09	5.02E-11
Cs-137	6.530E+03	D	7.E-08	1.31E-11	8.63E-09	5.00E-04
Ba-137m ^e	3.0E+03	NA	NA	NA	NA	NA
Pm-147	4.9E+01	Y	6.E-08	9.800E-14	1.06E-08	3.03E-05
Sm-151	4.3E+01	W	4.E-08	8.60E-14	8.10E-09	3.09E-06
Eu-152	1.7E-02	W	1.E-08	3.40E-17	5.97E-08	9.01E-09
Eu-154	7.9E+00	W	8.E-09	1.58E-14	7.73E-08	5.42E-06
Eu-155	4.8E+00	W	4.E-08	9.60E-15	1.12E-08	4.77E-07
Th-231	2.1E-02	Y	3.E-06	4.20E-17	2.37E-10	4.42E-11
Pa-233	5.6E-03	Y	2.E-07	1.12E-17	2.58E-09	1.28E-10
U-234	5.10E+00	Y	2.E-11	1.02E-14	3.58E-05	1.62E-03
U-235	0.23	Y	2.E-11	4.60E-16	3.32E-05	6.78E-05
U-236	2.6E-02	Y	2.E-11	5.20E-17	3.39E-05	7.83E-06

Table 6-3. (continued).

Radionuclide	Specific Activity (pCi/g)	Class	DAC (μCi/cm ³) (10 CFR 835)	Air Concentration Worker is Immersed In (μCi/cm ³)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
Np-237	1.5E-01	W	2.E-12	3.00E-16	1.46E-04	1.94E-04
Pu-238	244	W	3.E-12	4.88E-13	1.06E-04	2.30E-01
Pu-239	24.69	W	2.E-12	4.94E-14	1.16E-04	2.54E-02
Pu-239/240	24.69	NA	NA	NA	NA	NA
Pu-240	24.69	W	2.E-12	4.940E-14	1.16E-04	2.54E-02
Pu-241	8.2E+00	W	1.E-10	1.64E-14	2.23E-06	1.62E-04
Am-241	23.32	W	2.E-12	4.66E-14	1.20E-04	2.48E-02
Total	NA	NA	NA	NA	NA	3.36E-01

a. CEDE – Committed effective dose equivalent.

b. DACs and dose conversion factors are for H-3 vapor. No class.

c. Kr-85 is a noble gas. No internal dose. Minor external dose from submersion.

d. No class, DAC, or dose conversion factor for Rh-106. Class, DAC, and dose conversion factor for Rh-106m used.

e. Ba-137m is included in the Cs-137 DAC and dose conversion factor.

NOTES:

Converting pCi/g(soil) To μCi/cm³ (airborne dust)

pCi/g(soil) * airborne dust concentration * 1E-12 Ci/pCi * μCi/1E-6 Ci => μCi/cm³ (airborne dust)

pCi/g(soil) * [2.000E3 μg/m³] * [1E-6 g/μg] * (1E-2 m/cm)³ * [1E-12 Ci/pCi] * [μCi/1E-6 Ci] => μCi/cm³ (airborne dust)

pCi/g(soil) * (2.000E-15 g – μCi/pCi – cm³) => μCi/cm³ (airborne dust)

Internal Dose

Internal Radiation Dose = Radioactivity Inhaled During Exposure Time (Intake) * Dose Conversion Factor

Radioactivity Inhaled During Exposure Time (Bq) = Actual Airborne Concentration (μCi/cm³) * Volume of Air Breathed in During Exposure Time (cm³)

Example

Pu-238

Actual Airborne Concentration = 244 pCi/g * (2.000E-15 g – μCi/pCi – cm³) = 4.880E-13 μCi/cm³

Exposure Time = 1 hr

Effective Dose Conversion Factor (W) = 1.06E-4 Sv/Bq (EPA 1988)

Standard Man (ICRP 1975, p. 346) Breathes 20 L/min (Shleien 1992, p. 499)

Radioactivity Inhaled During Exposure Time (Bq) = (4.880E-13 μCi/cm³) * (20 L/min) * (mL/1E-3 L) * (cm³/mL) * (1E-6 Ci/μCi) * (3.7E10 dis/sec/Ci) * (Bq/(dis/sec)) * 1 hr * [60 min/hr]

Radioactivity Inhaled During Exposure Time (Bq) = (4.880E-13 μCi/cm³) * (4.440E10 Bq·cm³/μCi) = 2.167E-2 Bq

Radioactivity Inhaled During Exposure Time of One Hour = 2.167E-2 Bq

Effective Dose (rem) = 2.167E-2 Bq * 1.06E-4 Sv/Bq * 100 rem/Sv * [mrem/1E-3 rem] = 0.2297 mrem

During Exposure Time of 1 hr = >0.2297 mrem

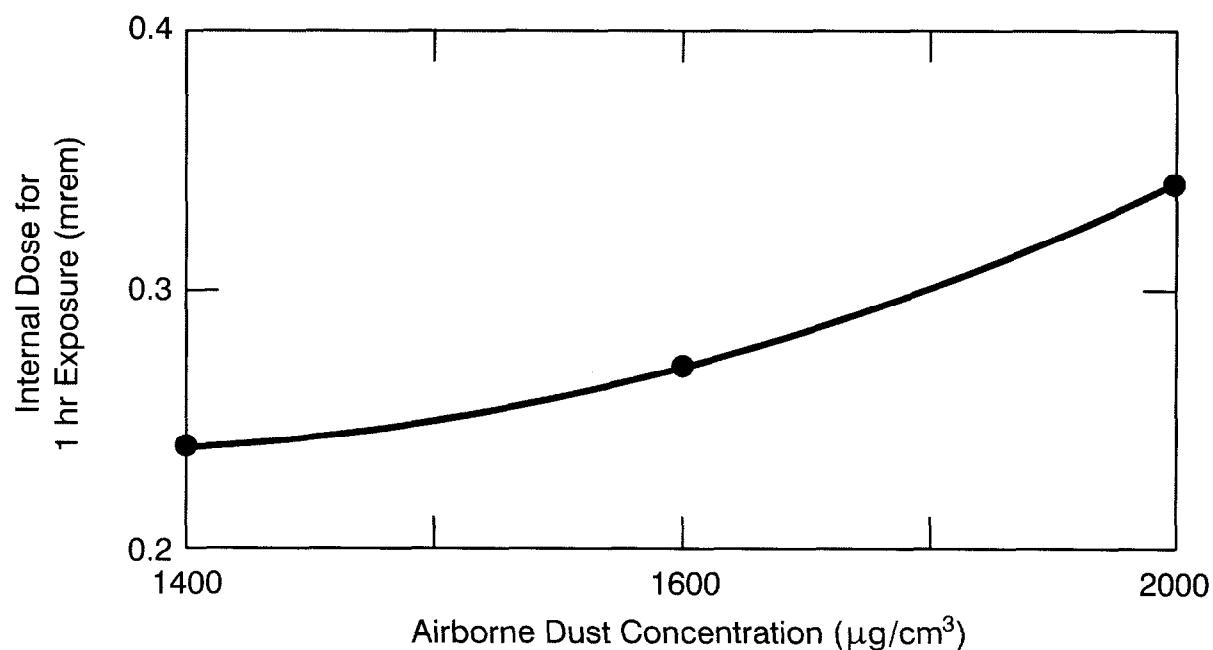
Effective Dose (rem) = (4.880E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * (4.440E10 Bq·cm³/μCi) * (100 rem/Sv) * (mrem/1E-3 rem)

Effective Dose (rem) = (4.880E-13 μCi/cm³) * (1.06E-4 Sv/Bq) * 4.440E15 Bq·cm³-mrem/Sv-μCi-hr) = 0.2297 mrem

Table 6-4. Internal radiation dose from various concentrations of CPP-92 dust.

Airborne Dust Concentration ($\mu\text{g}/\text{m}^3$)	Internal Dose for 1 hr Exposure (mrem)
1400	0.24
1500	0.25 ^a
1600	0.27
2000	0.34

a. Determined from the plot of the calculated values in Figure 6-1.



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Figure 6-1. Internal radiation dose from various concentrations of CPP-92 dust.

7. LOOSE SURFACE CONTAMINATION BOUNDING ANALYSIS

Bounding analysis was performed to assess the radiation risk to workers from loose surface radioactive contamination. To evaluate the source terms in the form of loose surface contamination, all waste streams that will go through the SSSTF into the ICDF were evaluated. In the decontamination activities in the decontamination facility, any one of these waste streams could be present. The source term is the same as the one developed and described in Section 3. In Table 7-1, all radionuclides and the highest specific activities are listed from Table 3-1. The footnotes to Table 7-1 contain the details of the calculations and assumptions that were used.

In Appendix A, Section 3, “Contamination Regulatory Requirements,” the contamination limits are listed. Table 7-1 gives the specific contamination limit each radionuclide falls under. There are four contamination limits. Each limit is for specific radionuclides. As is shown in Table 7-1, for each radionuclide, its corresponding specific activity value is copied into the column that represents the contamination limit for that radionuclide.

From this analysis, it was determined that if less than 0.07 mg of contaminated soil per 100 cm² is present, then contamination limits will probably not be exceeded. This is not very much soil. This provides a basis that contaminated soil will probably need to be kept wet and a ventilation system is needed. Because of this radiological control issue, the decontamination area and stabilization treatment area within the contamination facility will have to have controlled access.

Table 7-1. Loosc surface contamination bounding analysis.

Radionuclide	Worst-Case Specific Activity (pCi/g)	Contamination Area Limit (dpm/100 cm ²)	Specific Activity (pCi/g) for Contamination Area Limit of 20 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 200 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 1000 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 10000 dpm/100 cm ²	Soil Mass Areal Density (g/100 cm ²)
H-3	2.2E+03	1.00E+04	NA	NA	—	2.2E3	NA
C-14	2.1E-03	1.00E+03	NA	NA	2.10E-03	NA	NA
K-40	3.370E+01	1.00E+03	NA	NA	33.7	NA	NA
Co-57	0.358	1.00E+03	NA	NA	0.36	NA	NA
Co-60	1.9E+04	1.00E+03	NA	NA	1.90E+04	NA	NA
Zn-65	1.0E-07	1.00E+03	NA	NA	1.50E-07	NA	NA
Se-79	7.5E+00	1.00E+03	NA	NA	7.5	NA	NA
Kr-85	5.3E+04	1.00E+03	NA	NA	5.30E+04	NA	NA
Sr-90	1.0E+06	200	NA	1.00E+06	—	NA	NA
Y-90	1.0E+06	1.00E+03	NA	NA	1.00E+06	NA	NA
Zr-93	3.9E+01	1.00E+03	NA	NA	39	NA	NA
Nb-93m	6.1E-01	1.00E+03	NA	NA	0.61	NA	NA
Tc-99	2.6E+02	1.00E+03	NA	NA	260	NA	NA
Rh-102	1.4E-03	1.00E+03	NA	NA	1.40E-03	NA	NA
Rh-106	5.2E-01	1.00E+03	NA	NA	0.52	NA	NA
Ru-106	5.2E-01	1.00E+03	NA	NA	0.52	NA	NA
Pd-107	2.8E-01	1.00E+03	NA	NA	0.28	NA	NA
Ag-108m	64.16	1.00E+03	NA	NA	64.16	NA	NA
Cd-113m	7.4E+01	1.00E+03	NA	NA	74	NA	NA
Sn-121m	1.2E+00	1.00E+03	NA	NA	1.2	NA	NA
Sb-125	4.2E+02	1.00E+03	NA	NA	420	NA	NA
Te-125m	1.0E+02	1.00E+03	NA	NA	100	NA	NA

Table 7-1. (continued).

Radionuclide	Worst-Case Specific Activity (pCi/g)	Contamination Area Limit (dpm/100 cm ²)	Specific Activity (pCi/g) for Contamination Area Limit of 20 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 200 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 1000 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 10000 dpm/100 cm ²	Soil Mass Areal Density (g/100 cm ²)
Sn-126	6.7E+00	1.00E+03	NA	NA	6.7	NA	NA
Sb-126	9.4E-01	1.00E+03	NA	NA	0.94	NA	NA
Sb-126m	6.7E+00	1.00E+03	NA	NA	6.7	NA	NA
I-129	3.7E+00	20	3.7	NA	NA	NA	NA
Cs-134	994	1.00E+03	NA	NA	994.3	NA	NA
Cs-135	1.6E+00	1.00E+03	NA	NA	1.6	NA	NA
Cs-137	4.112E+06	1.00E+03	NA	NA	4.11E+06	NA	NA
Ba-137m	1.1E+06	1.00E+03	NA	NA	1.10E+06	NA	NA
Ce-144	880	1.00E+03	NA	NA	880.4	NA	NA
Pr-144	8.0E-02	1.00E+03	NA	NA	8.00E-02	NA	NA
Pr-144m	1.2E-03	1.00E+03	NA	NA	1.20E-03	NA	NA
Pm-146	2.6E-01	1.00E+03	NA	NA	0.26	NA	NA
Pm-147	1.7E+04	1.00E+03	NA	NA	1.70E+04	NA	NA
Sm-151	1.5E+04	1.00E+03	NA	NA	1.50E+04	NA	NA
Eu-152	8.3E+04	1.00E+03	NA	NA	8.30E+04	NA	NA
Eu-154	4.9E+04	1.00E+03	NA	NA	4.90E+04	NA	NA
Eu-155	8.224E+03	1.00E+03	NA	NA	8.22E+03	NA	NA
Tl-208	9.0E-03	1.00E+03	NA	NA	9.00E-03	NA	NA
Pb-209	2.2E-06	1.00E+03	NA	NA	2.20E-06	NA	NA
Pb-212	2.5E-02	1.00E+03	NA	NA	2.50E-02	NA	NA
Bi-212	2.5E-02	1.00E+03	NA	NA	2.50E-02	NA	NA
Po-212	1.5E-02	1.00E+03	NA	NA	1.50E-02	NA	NA
Po-216	2.5E-02	20	2.5E-02	NA	NA	NA	NA
Rn-220	2.5E-02	20	2.5E-02	NA	NA	NA	NA

Table 7-1. (continued).

Radionuclide	Worst-Case Specific Activity (pCi/g)	Contamination Area Limit (dpm/100 cm ²)	Specific Activity (pCi/g) for Contamination Area Limit of 20 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 200 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 1000 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 10000 dpm/100 cm ²	Soil Mass Areal Density (g/100 cm ²)
Ra-224	2.5E-02	200	NA	2.5E-02	NA	NA	NA
Ra-226	4.5E+01	20	45	NA	NA	NA	NA
Th-228	2.9E-01	20	0.29	NA	NA	NA	NA
Th-230	3.5	20	3.5	NA	NA	NA	NA
Th-230/U-234	3.50	NA	NA	NA	NA	NA	NA
Th-231	7.3E+00	1.00E+03	NA	NA	7.3	NA	NA
Th-232	2.12	20	2.12	NA	NA	NA	NA
Th-234	7.8E-02	1.00E+03	NA	NA	7.80E-02	NA	NA
Pa-231	3.2E-03	20	3.20E-03	NA	NA	NA	NA
Pa-233	2.0E+00	NA	NA	NA	NA	NA	NA
Pa-234m	7.8E-02	NA	NA	NA	NA	NA	NA
U-232	2.4E-02	200	NA	2.40E-02	NA	NA	NA
U-233	1.2E-03	NA	NA	NA	NA	NA	NA
U-233/234	1.04	NA	NA	NA	NA	NA	NA
U-234	2.7E+02	NA	NA	NA	NA	NA	NA
Th-230/U-234	3.50E+00	NA	NA	NA	NA	NA	NA
U-235	7.3E+00	1.00E+03	NA	NA	7.3	NA	NA
U-235/236	1.00E-01	NA	NA	NA	NA	NA	NA
U-236	9.2E+00	NA	NA	NA	NA	NA	NA
U-238	5.210E+01	1.00E+03	NA	NA	52.1	NA	NA
Np-237	5.50E+00	20	5.5	NA	NA	NA	NA
Np-239	1.5E-02	20	1.50E-02	NA	NA	NA	NA
Pu-238	7.607E+03	20	7.60E+03	NA	NA	NA	NA
Pu-239	324	NA	NA	NA	NA	NA	NA

Table 7-1. (continued).

Radionuclide	Worst-Case Specific Activity (pCi/g)	Contamination Area Limit (dpm/100 cm ²)	Specific Activity (pCi/g) for Contamination Area Limit of 20 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 200 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 1000 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 10000 dpm/100 cm ²	Soil Mass Areal Density (g/100 cm ²)
Pu-239/240	324	NA	NA	NA	NA	NA	NA
Pu-240	324	NA	NA	NA	NA	NA	NA
Pu-241	2.9E+03	20	2.90E+03	NA	NA	NA	NA
Pu-242	1.1E-02	20	1.10E-02	NA	NA	NA	NA
Am-241	7.5E+02	20	751.8	NA	NA	NA	NA
Am-242m	2.1E-03	20	2.10E-03	NA	NA	NA	NA
Am-242	2.1E-03	20	2.10E-03	NA	NA	NA	NA
Am-243	1.5E-02	20	1.50E-02	NA	NA	NA	NA
Cm-244	8.2E-02	20	8.20E-02	NA	NA	NA	NA
<i>S_L</i>			1.13E+04	NA	NA	NA	7.97E-04
			Is SUM				
				1.00E+06	NA	NA	9.01E-05
				Is SUM			
					6.46E+06	NA	6.97E-05
					Is SUM		
						2.2E3	2.05
						Is SUM	

Table 7-1. (continued).

Radionuclide	Worst-Case Specific Activity (pCi/g)	Contamination Area Limit (dpm/100 cm ²)	Specific Activity (pCi/g) for Contamination Area Limit of 20 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 200 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 1000 dpm/100 cm ²	Specific Activity (pCi/g) for Contamination Area Limit of 10000 dpm/100 cm ²	Soil Mass Areal Density (g/100 cm ²)
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NOTES:

From the following table (see RCM [Radiological Control Department 2000], Section 235 [p. 2-14]), the specific contamination limit for each of the individual radionuclides was determined. Then the worst-case specific activity for each individual radionuclide was placed under the appropriate column for the corresponding specific contamination limit. The specific activity values in each column was added for a total. Next this total amount was divided into the specific contamination limit to obtain a soil mass areal density. The minimum soil mass areal density is used to give the minimum amount of fugitive dust that can result in the area becoming a Contamination Area. See below for an example of the calculations performed in the spreadsheet.

Table 2-2. Summary of Surface Contamination Values

Radionuclide	Removable (dpm/100 cm ²)
U-natural, U-235, U-238, and associated decay products	1,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20
Th-nat, Th-232, Sr-90 6 , Ra-223, Ra-224, U-232, I-126, I-131, I-133	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90 .	1,000 beta-gamma
Tritium and tritiated compounds	10,000

Po-216, Rn-220, and Th-232 do not fall into a specific contamination limit.

But for this analysis to be conservative these radionuclides were placed under the 20 dpm/100 cm² limit. This is especially conservative for Rn-220 that is a noble gas. Kr-85 is also a noble gas.

Example Calculation:

Pu-238 worst-case specific activity is 7.607E3 pCi/g

Pu-241 worst-case specific activity is 2.9E3 pCi/g

Both radionuclides fall under the contamination limit of 20 dpm/100 cm²

$$7.607E3 \text{ pCi/g} + 2.9E3 \text{ pCi/g} = 1.051E4 \text{ pCi/g}$$

$$\text{Soil mass areal density} = [(20 \text{ dpm/100 cm}^2)/1.051E4 \text{ pCi/g}] * (\text{Ci}/3.7E10 \text{ dis/s}) * (\text{pCi}/1E-12 \text{ Ci}) * (\text{min}/60 \text{ sec}) = 8.573E-4 \text{ g/100 cm}^2$$

$$\text{Soil mass areal density} = [(20 \text{ dpm/100 cm}^2)/1.051E4 \text{ pCi/g}] * 0.4505 \text{ pCi} - \text{min/dis} = 8.573E-4 \text{ g/100 cm}^2$$

Note: This is $(1.051E4 \text{ pCi/g})/(1.13E4 \text{ pCi/g}) * 100 = 93\%$ of the total specific activity for the 20 dpm/100 cm² column.

8. SSSTF/ICDF RADIOLOGICAL CONTROL INSTRUMENTATION

The requirements are that radiation is to be controlled at the source. Radiological control instrumentation is required to verify that this is being accomplished. The radiological control instrumentation will, in general, be used interchangeably between the SSSTF and the ICDF. Table 8-1 lists the types, quantities, and approximate cost of fixed and portable radiological control instruments for the SSSTF and the ICDF.

The number of instruments takes into consideration that, at any given time, some of the instruments will be out-of-service to receive calibration and maintenance.

The bounding external radiation exposure rates (see Sections 3 and 5) show significant radiation fields. High Radiation Areas (100 mR/hr at 30 cm) are expected. Therefore, ion chamber portable survey instruments are required. The bounding internal radiation dose (see Sections 4 and 6) shows that a small amount of contaminated dust that is airborne can reach RadCon limits. Contaminated dust concentrations are 43 mg/m³ for bounding all waste streams and 1,500 mg/m³ for waste streams CPP-92, CPP-98, and CPP-99. This demonstrates that CAMs and portable air samplers are required.

The loose surface contamination bounding analysis (see Section 7) shows that a very small amount of contaminated soil (0.07 mg/100cm²) can result in a contamination area. Therefore, GM or scintillation stationary survey instruments and a proportional counter to measure activity on CAM filters and surface wipe smears are required. GM or scintillation stationary survey instruments are required at all personnel exits from the decontamination bay and the treatment/stabilization areas. A PCM will be used to do a whole body survey at the main exit for the decontamination bay and the treatment/stabilization areas. Although the PCM is a best management practice, it will greatly assist in meeting ALARA requirements. A PCM is faster and more accurate than using a GM or scintillation stationary survey instrument to perform a whole body survey. The requirements are to control radioactive contamination at the source. A PCM will significantly aid in preventing radioactive contamination from leaving the source/area on personnel. Near the PCM, a GM or scintillation stationary survey instrument will be located to survey tools, etc. and also for use when the PCM is out of service for calibration or maintenance. Also, GM or scintillation survey instruments will be used to detect contamination on large area wipes such as maslin cloth.

Based on the assumption that INTEC will operate the SSSTF, INTEC will provide and maintain the RadCon instrumentation. Monitoring for airborne radioactivity, surface contamination, and direct radiation is necessary to provide feedback that radiological controls are adequate and have not been compromised.

Table 8-1. Required SSSTF/ICDF radiological control instruments.

Facility	Rad Con Instrument	Quantity ^a	Location	Approximate Cost ^b	Notes
SSSTF	Continuous air monitor (CAM)	3	Decontamination Building (Exact location TBD—depends on air flow and radiation source term analysis)	Beta/gamma-- \$10,000/each Alpha-- \$13,000/each	Two separate ventilation systems. One CAM for the decon side. One CAM for the treatment side. One CAM for spare for repair/calibration purposes. (TBD if alpha CAM is needed per analysis.)
	Personnel contamination monitor	1	Decontamination Building	\$50,000	Needed for whole body frisk
	Proportional counter	1	Decontamination Building (The instrument will support both the SSSTF and the ICDF.)	\$6,000	To analyze the radioactivity on smears taken during surveys of trucks after unloading contaminated soil. Also smears taken during routine surveys.
	GM or scintillation stationary survey instrument	1	Decontamination Building	\$700	Backup for the personnel contamination monitor
	GM or scintillation stationary survey instrument	3	Decontamination Building (Inside, next to each roll-up door that is on the exterior of building)	\$700/each	Hand and foot frisk.
	GM or scintillation portable survey instrument	4	Stored in Decontamination Building	\$700/each	Used to perform surveys to assess the adequacy of radiation contamination controls.
	Ion chamber portable survey instrument	3	Stored in Decontamination Building	\$1,000/each	Used to perform surveys of direct radiation (external dose rate) to determine adequacy of time, distance, and shielding controls.
	Micro-R meter	1	Stored in Decontamination Building (The instrument will support both the SSSTF and the ICDF.)	\$1,000	Used to perform surveys of contaminated soil that has low dose rate radiation fields.
	Portable air sampler	4	Stored in Decontamination Building (The instrument will support both the SSSTF and the ICDF.)	\$500	Used for spot-sampling for airborne radioactivity.
ICDF	Continuous air monitor (CAM)	4	Downwind of dumping activities.	\$10,000/each	Used to assess the adequacy of radiological controls.
	GM or scintillation portable survey instrument	8	Stored in Decontamination Building	\$700/each	Used to perform surveys of trucks after unloading contaminated soil. Also used to perform surveys to assess the adequacy of radiological controls.

Table 8-1. (continued).

Facility	Rad Con Instrument	Quantity ^a	Location	Approximate Cost ^b	Notes
	Ion chamber portable survey instrument	4	Stored in Decontamination Building	\$1,000/each	Used to perform surveys of direct radiation (external dose rate) of trucks.

a. A. D. Summers, BBWI, personal communication, with Alan Nellesen (formerly RadCon Supervisor at ERDF-Hanford), currently a BBWI employee, April 25, 2001.
b. A. D. Summers, BBWI, personal communication, with Byron Christiansen of the Health Physics Instrument Laboratory (HPIL), April 11, 2001, and April 25, 2001. These values are vendor costs without INEEL adders.

9. REFERENCES

- 10 CFR 835, 2000, "Occupational Radiation Protection," *Code of Federal Regulations*, Office of the Federal Register, January 2000.
- ACGIH, 1999, *Threshold Limit Values Booklet*, American Conference of Governmental Industrial Hygienists, 1999.
- DOE-ID, 1994, *Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL*, DOE/ID-10389, Rev. 6, January 1994.
- DOE-ID, 2000, *CERCLA Waste Inventory Database Report for the Operable Unit 3-13 Waste Disposal Complex*, DOE/ID-10803, Rev. 0, December 2000.
- EDF-ER-264, 2001, "INEEL CERCLA Disposal Facility Design Inventory," Rev. 0, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, July 2001.
- EPA, 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion – Federal Guidance Report No. 11*, EPA-520/1-88-020, U.S. Environmental Protection Agency, September 1988.
- Grove Engineering, 1999, MicroShield, Version 5.05, Rockville, Maryland.
- ICRP, 1975, *Report of the Task Group on Reference Man*, International Commission on Radiological Protection, Publication 23, Oxford, Great Britain, Pergamon Press, p. 346.
- MCP-91, 2000, "ALARA Program and Implementation," Rev. 11, Radiation Protection, Idaho National Engineering and Environmental Laboratory, July 2000.
- Radiological Control Department, 2000, *Manual 15A - Radiation Protection - INEEL Radiological Control Manual*, Rev. 6, PRD-183, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho, July 2000.
- Shleien, B., ed., 1992, *The Health Physics and Radiological Health Handbook, Revised Edition*, Silver Spring, MD: Scinta, Inc.

Appendix A

Radiological Control Requirements

Appendix A

Radiological Control Requirements

The purpose of this appendix is to list all relevant radiological control regulatory requirements that the design may have to meet for worker safety. The requirements are based on six categories: (1) inhalation, (2) external radiation, (3) contamination, (4) air monitoring for airborne radioactivity (5) instrumentation, and (6) ALARA requirements. Under each of these categories are listed the regulatory requirements. The requirements are from the *INEEL Radiological Control Manual* with 10 CFR 835 cross-referenced. The ALARA requirements are from MCP-91, "ALARA Program and Implementation."

(1) INHALATION Regulatory Requirements -10 CFR 835 and RCM (PRD-183, Rev. 6) Requirements

Table A-1. Inhalation Requirements

Section No.	Requirement
RCM 381 (p3-28)	Radiological Design Criteria: 1. For areas of occupancy is not continuous, the design objective shall be to maintain doses ALARA and below 20% of the occupational dose limits provided in Table 2-1 (see 835.1002[b]). DOE recommends that design criteria be established to limit individual worker doses below 0.25 mrem per hour (500 mrem TEDE per year).
RCM 381 (p3-28)	Radiological Design Criteria: 2. For control of airborne radioactivity, the design objective shall be to avoid releases to the work place atmosphere under normal conditions and, under any conditions, to control inhalation by workers to levels that are ALARA. Confinement and ventilation shall normally be used (see 835.1002[c]).
RCM 381 (p3-28)	Radiological Design Criteria: 4. In justifying facility design and physical controls, optimization methods shall be used (see 835.1002[a]).
RCM 316 (p3-6)	1. The primary methods used to maintain individual internal doses ALARA shall be physical design features, such as confinement, ventilation, and remote handling (see 835.1001[a]). The design objective shall be, under normal conditions, to avoid releases of radioactive material to the workplace atmosphere. The objective, under all conditions, shall be to control inhalation of radioactive material to levels that are ALARA (see 835.1002[c]). See ALARA requirements sections.

(2) EXTERNAL (DIRECT) RADIATION Regulatory Requirements - 10 CFR 835 and RCM Requirements

Table A-2. External (direct) radiation requirements.

Section No.	Requirement
RCM 234 (p2-13)	Radiation Area: levels could result in an individual receiving > 0.005 rem in 1 hour at 30 cm (see 835.603[a])
RCM 234 (p2-13)	High Radiation Area: Radiation levels could result in an individual receiving > 0.1 rem in 1hour at 30 cm (see 835.603[b])
RCM 381 (p3-28)	Radiological Design Criteria: 1. For areas of occupancy is not continuous, the design objective shall be to maintain doses ALARA and below 20% of the occupational dose limits provided in Table 2-1 (see 835.1002[b]). DOE recommends that design criteria be established to limit individual worker doses below 0.25 mrem per hour (500 mrem TEDE per year).

Table A-2. (continued).

Section No.	Requirement
(RCM Table 2-1.) Summary of Occupational Dose Limits	
Type of Exposure	Limit
General Employee: Whole Body (internal + external) (TEDE) (see 835.202[a][1])	5 rem/year
General Employee: Lens of the Eye (external) (see 835.202[a][3])	15 rem/year
General Employee: Skin and extremities (external shallow dose) (see 835.202[a][4])	50 rem/year
General Employee: Any organ or tissue (other than lens of eye) (internal + external) (see 835.202[a][2])	50 rem/year
Declared Pregnant Worker: Embryo/Fetus (internal + external) (see 835.206[a])	0.5 rem/gestation period
RCM 381 (p3-28)	Radiological Design Criteria: 4. In justifying facility design and physical controls, optimization methods shall be used (see 835.1002[a]).
	See ALARA requirements section.

(3) CONTAMINATION Regulatory Requirements - 10 CFR 835 and RCM Requirements

Table A-3. Contamination requirements.

Section No.	Requirement
RCM 235 (p2-14)	Contamination Area: Removable contamination levels ($\text{dpm}/100 \text{ cm}^2$) > Table 2-2 values but $\leq 10 \times$ Table 2-2 values (see 835.603[e])
(RCM Table 2-2). Summary of Surface Contamination Values	
Radionuclides	Removable ($\text{dpm}/100 \text{ cm}^2$)
U-natural, U-235, U-238, and associated decay products	1,000 alpha
Transuramics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20
Th-nat, Th-232, Sr-90 ⁶ , Ra-223, Ra-224, U-232, I-126, I-131, I-133	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90 ^{4,7} .	1,000 beta-gamma
<u>Tritium and tritiated compounds⁵</u>	10,000
Footnotes to RCM table 2-2	NA
4. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 that has been separated from the other fission products or mixtures where the Sr-90 has been enriched (see 10 CFR 835 App. D, note 5).	
5. Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface radioactivity value provided in this table is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply (see 10 CFR 835 App. D, note 6).	
6. These values will be applied to total Sr-90/Y-90 activity resulting from processes involving the separation or purification of Sr-90.	
7. These values will be applied to total Sr-90/Y-90 activity resulting from the presence of Sr-90 in mixed fission products.	
RCM 235 (p2-14)	High Contamination Area: Removable contamination levels ($\text{dpm}/100 \text{ cm}^2$) > $100 \times$ Table 2-2 values (see 10 CFR 835.603[f])

Table A-3. (continued).

Section No.	Requirement
RCM 235 (p2-14)	Fixed Contamination: Removable contamination levels < Table 2-2 removable values and total contamination levels > Table 2-2 total values
RCM 235 (p2-14)	Soil Contamination Area: Contaminated soil not releasable in accordance with DOE 5400.5.
RCM 235 (p2-14); 233 (p2-11)	1. A radiological buffer area shall be established for contamination control adjacent to any entrance to or exit from a contamination, high contamination, or airborne radioactivity area. The size of the radiological buffer area will be commensurate with the potential for the spread of contamination.
RCM 381 (p3-28)	Radiological Design Criteria: 3. For materials used in facility construction and modification, the design objective shall be to select materials that facilitate operations, maintenance, decontamination, and decommissioning (see 10 CFR 835.1002[d]). Components will be selected to minimize the buildup of radioactivity. Control of surface contamination should be achieved by containment of radioactive material.
RCM 381 (p3-28)	Radiological Design Criteria: 4. In justifying facility design and physical controls, optimization methods shall be used (see 10 CFR 835.1002[a]).
RCM 381 (p3-28)	Radiological Design Criteria: 5. Support facilities should be provided for donning and removal of protective clothing and for personnel monitoring, when required.
RCM 381 (p3-28)	Radiological Design Criteria: 7. Existing facility designs that have office space and lunchrooms or eating areas within radiological areas, radioactive material areas, and radiological buffer areas require priority attention. Generally: <ul style="list-style-type: none"> a. Locating lunch rooms or eating areas, restrooms, drinking fountains, showers, and similar facilities and devices is strongly discouraged within these areas b. Locating office spaces within these areas is strongly discouraged; to the extent that such space is essential to support radiological work, steps will be taken to preclude unnecessary occupancy.
RCM 421 (p4-7); Table 2-2 (p2-9)	Release to Controlled Areas. 3. If inaccessible surfaces are likely to be contaminated to levels in excess of the Table 2-2 values, then..... (see 835.1101[a][2]) If it is necessary to release the material or equipment from the radiological area, the <u>material or equipment will be disassembled</u> to the extent necessary to perform adequate surveys. <ul style="list-style-type: none"> 4. Removable contamination levels shall be less than Table 2-2 values prior to releasing material and equipment for unrestricted use in controlled areas (see 835.1101[a][1] & [a][2]). 6. Material and equipment with total or removable contamination levels exceeding Table 2-2 values may be moved on site from one radiological area to another if appropriatecontrols are established and implemented (see 10 CFR 835.1101[b]). (see 10 CFR 835 Appendix D).
RCM 422 (p4-8)	Release to Uncontrolled Areas: 1. DOE 5400.5 describes radiological criteria for releasing material to uncontrolled areas.
RCM 422 (p4-8)	Release to Uncontrolled Areas: 2. DOE 5400.5 will be used by the INEEL to obtain guidance on obtaining approvals on a case-by-case basis for releasing material that has been contaminated in depth or volume, such as activated material or smelted contaminated material. <ul style="list-style-type: none"> a. DOE-ID: When referring to DOE 5400.5, Figure IV-1, use the following values for allowable total residual surface contamination ($dpm/100 cm^2$) for transuranics, I- 25, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, and Pa-231: <ul style="list-style-type: none"> (1) Average = 100 (2) Maximum = 300 (3) Removable = 20

Table A-3. (continued).

Section No.	Requirement
RCM 463 (P4-15)	<p>Decontamination:</p> <p>2. Work preplanning should include consideration of the handling, temporary storage, and decontamination of materials, tools, and equipment.</p> <p>3. Decontamination activities should be controlled to prevent the spread of contamination.</p> <p>4. Water and steam are the preferred decontamination agents. Other cleaning agents should be selected based upon their effectiveness, hazardous properties, amount of waste generated, and ease of disposal.</p> <p>See ALARA requirements section.</p>

(4) AIR MONITORING FOR AIRBORNE RADIOACTIVITY Regulatory Requirements - 10 CFR 835 and RCM Requirements

Table A-4. Air monitoring for airborne requirements.

Section No.	Requirement
RCM 235 (p2-14)	Airborne Radioactivity Area: Airborne concentrations ($\mu\text{Ci}/\text{mL}$) above background: 1) are $>$ the applicable DAC values; or 2) could result in an individual (w/o respirator) receiving an intake > 12 DAC-hrs in a week (see 10 CFR 835.603[d])
RCM 555 (p5-18)	2. Air sampling equipment shall be used where an individual is likely to receive an annual exposure of 40 or more Derived Air Concentration (DAC) hours (see 10 CFR 835.403[a][1]). This intake generally represents a committed effective dose equivalent to an individual of approximately 100 mrem. Samples shall also be taken as necessary to characterize the hazard in areas where respiratory protection devices have been prescribed for protection against airborne radionuclides (see 10 CFR 835.403[a][2]). Air samples should be adequate to evaluate the concentrations of airborne radioactive materials at the individual's work locations.

See ALARA requirements section.

(5) RADIOLOGICAL CONTROL INSTRUMENTATION Regulatory Requirements - 10 CFR 835 and RCM Requirements

Table A-5. Radiological control instrumentation requirements.

Section No.	Requirement
RCM 555	<p>555 Airborne Radioactivity Monitoring</p> <p>1. Selection of air monitoring equipment should be based on the specific job being monitored. Air monitoring equipment includes portable and fixed air sampling equipment and continuous air monitors.</p>
RCM 555	<p>2. Air sampling equipment shall be used where an individual is likely to receive an annual exposure of 40 or more Derived Air Concentration (DAC) hours (see 10 CFR 835.403[a][1]). This intake generally represents a committed effective dose equivalent to an individual of approximately 100 mrem.</p> <p>3. Real-time (or continuous) air monitors are used to provide early warning to individuals of events that could lead to substantial unplanned exposures to airborne radioactivity. Such exposures could result from a breakdown of engineered controls or improper establishment of boundaries during work that creates airborne radioactivity. Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material (see 10 CFR 835.403[b]).</p>

Table A-5. (continued).

Section No.	Requirement
	<ol style="list-style-type: none">4. Air sampling equipment should be positioned to measure air concentrations to which individuals are exposed.5. Continuous air monitors should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.6. Real-time air monitoring equipment required by Article 555.3 should have alarm capability and sufficient sensitivity to alert individuals that immediate action is necessary to minimize or terminate inhalation exposures.
RCM 553	<p>Area Radiation Monitors</p> <ol style="list-style-type: none">1. In addition to the requirements and recommendations of Article 551, area radiation monitors (not to include area monitoring dosimeters discussed in Article 514) should be installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates prior to personnel entry. <p>See ALARA requirements section.</p>

(6) ALARA REGULATORY REQUIREMENTS – MCP-91 REQUIREMENTS

MCP-91 Section 4.3.11

Project Managers and Radiological Support: Evaluate *optimization methods* (see def.) to ensure that occupational exposure to personnel is maintained as low as reasonably achievable (ALARA) when developing, documenting, and justifying facility design and physical controls.

MCP-91 Section 4.4 (ALARA Design Review Process)

4.4.1 Designers: Request radiological support early (by Title I design review) in the planning and design of new facilities or modification of existing facilities that are associated with handling, processing, or storage of radioactive material in accordance with 10 CFR 835 subpart K.

4.4.2 Designers/Radiological Support: Use form 431.01, Radiological Control Design Review or equivalent (containing at least the information on the form), to develop methods to implement ALARA processes into the early design and to support design modifications.

4.4.3 Radiological Support: Recommend ALARA measures to facilitate control of radiation exposure in controlled areas through facility and equipment design and administrative control.

4.4.4 Perform design reviews early in the design stage and throughout the entire work activity or work project using form 431.01 or equivalent (containing at least the information on the form).

4.4.4.1 Ensure that reasonable radiological considerations have been integrated into the design, the construction procedures, and the plans for decommissioning.

4.4.4.2 Evaluate, at a minimum, the primary methods used as physical design features, including:

- A. general configuration of the facility
- B. confinement and ventilation
- C. remote handling and remote equipment
- D. shielding
- E. containment
- F. decontamination capabilities.

4.4.7 Radiological Support/Managers: Use optimization methods for ALARA in developing and justifying facility design and physical controls during the design of new facilities or modification of existing facilities.

NOTE: Step 4.4.7.1 design criteria is from 10 CFR 835.1002.(b) as a requirement for occupational personnel protection. It is not intended that routine continuous occupancy (2,000 hours/year) in radiation fields of 0.5 mrem/hr will be acceptable for workers at the INEEL.

4.4.7.1 Ensure the design objective for controlling personnel exposures from external sources of radiation in areas of continuous occupancy (2,000 hours/year) is to maintain exposure levels below an average of 0.5 mrem per hour and as far below this average as is reasonably achievable (see RCM revision 3 Chapter 3, Part 8).

4.4.7.2 Ensure the design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above are as low as reasonably achievable (ALARA) and do not exceed 20 % of the applicable standards in 10 CFR 835.202.”

4.4.7.3 Use the following guidelines as basic design criteria for new or modified facilities at the INEEL:

- A. Full-time occupancy (an area where one may be expected to spend all or most of his/her workday)—use a design value of 0.1 mrem/hour as the design objective
- B. Full-time access area (an area where access has no physical or administrative control on entry)—use a design value of 1.0/t mrem/hour in which “t” is the maximum average time in hours per day that the area is expected to be occupied by any one individual (at least hour).

4.4.7.4 When optimization studies prove the above would not be cost-beneficial, use higher dose rates and limit or control access to such areas.

4.4.7.5 Ensure the design objective for control of airborne radioactive materials under normal conditions is to avoid releases to the work place atmosphere and to control inhalation of such materials by workers to levels that are as low as reasonably achievable.

4.4.7.6 Ensure the design or modification of a facility and the selection of materials includes features that facilitate operations, maintenance, decontamination, and decommissioning.

4.4.8 Designers/Project Managers: Document radiological design reviews using form 431.01, Radiological Control Design Review, or equivalent (containing at least the information on the form) and records of temporary shield and portable ventilation installation and removal as a record with the design review package.

NOTE: Decisions on the cost/benefit of reducing occupational dose involves judgments on the relative value of social, technical, and economic factors, considering the benefits arising out of the activity, potential detriments from the activity, and possible detriments from not performing the activity.

4.4.10 Project Managers and Radiological Support: Use optimization techniques, including cost/benefit analysis, and a person rem value of \$6,500.00 (or the value from 4.4.10.1 - 4.4.10.2 when approved for use) as a fundamental part of radiological design analysis and work review to establish ALARA Protective Measures (APM) to minimize radiological exposure (Appendix A provides examples.)

4.4.10.1 Use \$6,500 as the Company value of person rem for determination of ALARA protective measures.

Section 6

Optimization method. A documented method that describes how the factors affecting a protection decision, i.e., social, technical, economic, practical, and public policy, are assigned values to compare detriments and benefits.

Appendix B

Radiological Control Design Review Form

RADIOLOGICAL CONTROL DESIGN REVIEW

Radiological Engineer: A. D. Summers Date: May 5, 2001

Project Design Title: Staging, Storage, Sizing, and Treatment Facility (SSSTF) Design

Project Manager: R. Lee Davison

Required form (or equivalent) for Title I design review of facility designs/modifications associated with handling, processing, or storage of radioactive material.

1. The original of this form shall be filed in the original project file. RadCon offices should retain a file copy as documentation of the review.
2. Use the checklist (yes/no/na) to identify issues that have been evaluated and comments to resolve concerns.

Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input checked="" type="checkbox"/>	1.	Have optimization methods/cost-benefit analysis been applied to the facility design to ensure that occupational radiation exposure is maintained ALARA?
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Comment: Bounding analysis shows that the maximum radiation dose is small.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	2.	Have sufficient engineering controls for radiation protection been incorporated into the design to prevent undue health and safety risks to plant personnel, the public and the environment?
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Comment: The Decontamination Facility will have a ventilation system including HEPA filters. This will not be for primary control. Since the mixer unit has not yet been designed this criteria will need to be applied to it when it is in the design process.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	3.	Are radiological control concerns such as access/egress controls, contamination control barriers and containments, and radiation control boundaries addressed in the facility design?
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Comment: Listed in EDF-INTEC-2001-005, Section titled, "Review of SSSTF Design Radiological Control Issues."

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	4.	Have specific control devices for reducing occupational radiation exposure such as, shielding, HEPA filtered hoods, glove-boxes, equipment containments, interlocks, barricades, shielded cells, installed decontamination systems, and remote operations been evaluated and used to the maximum extent practical?
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Comment: The Decontamination Facility will have a ventilation system including HEPA filters. This will not be for primary control. Since the mixer unit has not yet been designed this criteria will need to be applied to it when it is in the design process.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	5.	Does the ventilation system design provide sufficient capacity and proper flow pattern to prevent the spread and/or build-up of loose surface and airborne contamination?
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Comment: A review shows the adequacy of the ventilation system.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	6.	Are sources of radiological or mixed waste generation and their disposal methods identified in the facility design?
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Comment: Described in DOE/ID-10886, Rev. A, ICDF Complex Operations Waste Management Plan. Includes the SSSTF.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	7.	Does the radiological design of the facility comply with criteria established in DOE directives and standards, the INEEL Radiological Control Manual, and applicable federal codes?
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Comment: Since the mixer unit has not yet been designed this criteria will need to be applied to it when it is in the design process.

Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input checked="" type="checkbox"/>	8.	For modifications to an existing facility, will there be an increase in operations, maintenance, research, inspections, or decommissioning requirements involving the radiological control area(s)?
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Comment: SSSTF is a new facility.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	9.	Is fixed radiological monitoring instrumentation identified and adequate for the proposed facility design or modification?
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Comment: Listed in EDF-INTEC-2001-005, Section titled, "SSSTF/ICDF Radiological Control Instruments."

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	10.	Are the change rooms and personnel decontamination facilities sufficient in size and in the proper locations?
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Comment: Change rooms are in the Decontamination Facility. Personnel decontamination if needed will be done at INTEC.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	11.	Have space requirements for anticipated operations, maintenance, production, research and decommissioning in radiological control areas been evaluated?
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Comment: A review shows the adequacy of the space requirements. When the mixer unit is designed this will need to be re-evaluated.

Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input checked="" type="checkbox"/>	12.	For modification(s) to an existing facility, does the work involved making this modification have the potential to exceed ALARA review trigger levels?
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Comment: SSSTF is a new facility.

Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>	N/A <input type="checkbox"/>	13.	Will a new radiation source be created and if so, is there a potential that existing area dose rates will increase?
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Comment: The source terms are well characterized per EDF-ER-302.

Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>	14.	Review previous similar jobs, designs and processes with similar hazards. Are controls compatible?
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Comment: Based on trip to similar facilities at Hanford.

Appendix C

MicroShield Analysis for Exposure Rate from a Dump Truck Containing the Worst-Case Composite Waste Stream Soil

Appendix C

MicroShield Analysis for Exposure Rate from a Dump Truck Containing the Worst-Case Composite Waste Stream Soil

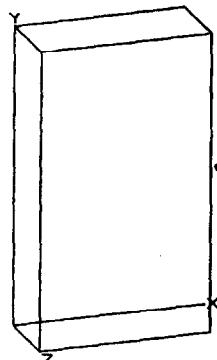
The computer model used is a suspended box in air. The orientation of the box is such that the dose receptor distance is in the direction of the x-axis. Soil is not in the computer code library. Compton scattering (photons interacting with electrons) which is the primary interaction depends on the effective atomic number (electron density). The effective atomic number of soil is approximately the same as concrete. Therefore concrete at the same density as the soil can be used in gamma ray shielding. Buildup is scattering of the gamma rays back into the dose receptor location and therefore concrete at soil density can be used. Concerning "lower energy cutoff limit" the libraries of attenuation coefficients in MicroShield do not include data for energies less than 0.015 MeV. In the current calculations 99% of the dose contribution comes from the 0.6 MeV energy group. This is because of Cs-137. The 0.015 MeV energy group has 12 orders of magnitude less exposure rate.

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTRU5.MS5
Run Date: June 13, 2001
Run Time: 5:06:04 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck5-WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield--30cm-file:dumptru5
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

#	X	Y	Z
1	274.4724 cm 9 ft 0.1 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTRU5.MS5
 Run Date: June 13, 2001
 Run Time: 5:06:04 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTRU5.MS5
 Run Date: June 13, 2001
 Run Time: 5:06:04 PM
 Duration: 00:00:14

Z Direction

20

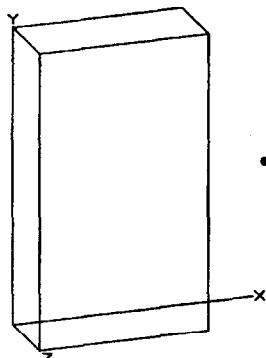
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			Fluence Rate		Exposure Rate mR/hr	Exposure Rate mR/hr
			No Buildup	With Buildup		
0.015	4.394e+04	4.095e-134	2.161e-29	3.513e-135	1.853e-30	
0.02	3.060e+06	1.422e-61	2.368e-27	4.927e-63	8.204e-29	
0.03	1.415e+11	1.532e-17	3.102e-17	1.518e-19	3.074e-19	
0.04	7.074e+10	2.160e-07	6.984e-07	9.552e-10	3.089e-09	
0.05	9.431e+09	3.316e-04	1.577e-03	8.832e-07	4.201e-06	
0.06	1.114e+08	3.458e-04	2.119e-03	6.868e-07	4.208e-06	
0.08	1.586e+09	2.716e-01	1.971e+00	4.298e-04	3.119e-03	
0.1	2.782e+10	2.612e+01	1.885e+02	3.996e-02	2.884e-01	
0.15	6.002e+07	3.016e-01	1.847e+00	4.967e-04	3.041e-03	
0.2	5.921e+09	6.088e+01	3.258e+02	1.075e-01	5.751e-01	
0.3	1.384e+10	3.133e+02	1.387e+03	5.943e-01	2.632e+00	
0.4	3.516e+09	1.320e+02	5.107e+02	2.572e-01	9.951e-01	
0.5	5.317e+08	2.925e+01	1.020e+02	5.741e-02	2.002e-01	
0.6	2.163e+12	1.620e+05	5.184e+05	3.163e+02	1.012e+03	
0.8	2.147e+10	2.616e+03	7.363e+03	4.975e+00	1.401e+01	
1.0	4.291e+10	7.626e+03	1.957e+04	1.406e+01	3.607e+01	
1.5	3.539e+10	1.245e+04	2.737e+04	2.094e+01	4.605e+01	
2.0	4.123e+02	2.325e-04	4.678e-04	3.596e-07	7.234e-07	
3.0	5.535e+03	5.919e-03	1.065e-02	8.030e-06	1.445e-05	
TOTALS:	2.538e+12	1.853e+05	5.753e+05	3.573e+02	1.113e+03	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTRU6.MS5
Run Date: June 13, 2001
Run Time: 5:09:51 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck6-WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield--1m-file:dumptru6
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

	X	Y	Z
# 1	344.424 cm	213.36 cm	53.34 cm
	11 ft 3.6 in	7 ft 0.0 in	1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTRU6.MS5
 Run Date: June 13, 2001
 Run Time: 5:09:51 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTRU6.MS5
 Run Date: June 13, 2001
 Run Time: 5:09:51 PM
 Duration: 00:00:14

Z Direction

20

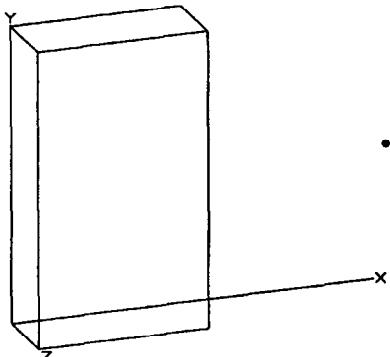
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		<u>Fluence Rate</u>		<u>Exposure Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>MeV/cm²/sec</u>	<u>With Buildup</u>	<u>mR/hr</u>	<u>With Buildup</u>
0.015	4.394e+04	3.651e-134	9.970e-30	3.131e-135		8.552e-31	
0.02	3.060e+06	1.073e-61	1.093e-27	3.716e-63		3.785e-29	
0.03	1.415e+11	1.451e-17	2.939e-17	1.438e-19		2.913e-19	
0.04	7.074e+10	2.110e-07	6.813e-07	9.331e-10		3.013e-09	
0.05	9.431e+09	2.947e-04	1.391e-03	7.850e-07		3.705e-06	
0.06	1.114e+08	2.786e-04	1.675e-03	5.533e-07		3.327e-06	
0.08	1.586e+09	1.850e-01	1.281e+00	2.927e-04		2.028e-03	
0.1	2.782e+10	1.596e+01	1.078e+02	2.442e-02		1.649e-01	
0.15	6.002e+07	1.631e-01	9.213e-01	2.686e-04		1.517e-03	
0.2	5.921e+09	3.147e+01	1.555e+02	5.554e-02		2.744e-01	
0.3	1.384e+10	1.561e+02	6.421e+02	2.961e-01		1.218e+00	
0.4	3.516e+09	6.458e+01	2.336e+02	1.258e-01		4.551e-01	
0.5	5.317e+08	1.414e+01	4.635e+01	2.775e-02		9.099e-02	
0.6	2.163e+12	7.760e+04	2.346e+05	1.515e+02		4.579e+02	
0.8	2.147e+10	1.236e+03	3.312e+03	2.350e+00		6.299e+00	
1.0	4.291e+10	3.567e+03	8.766e+03	6.575e+00		1.616e+01	
1.5	3.539e+10	5.728e+03	1.219e+04	9.637e+00		2.051e+01	
2.0	4.123e+02	1.060e-04	2.078e-04	1.640e-07		3.213e-07	
3.0	5.535e+03	2.676e-03	4.724e-03	3.630e-06		6.409e-06	
TOTALS:	2.538e+12	8.841e+04	2.600e+05	1.706e+02		5.030e+02	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTRU7.MS5
Run Date: June 13, 2001
Run Time: 5:12:44 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck7-WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield--9ft--file:dumptru7
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

	X	Y	Z
# 1	518.7696 cm 17 ft 0.2 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm³</u>
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTRU7.MS5
 Run Date: June 13, 2001
 Run Time: 5:12:44 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTRU7.MS5
 Run Date: June 13, 2001
 Run Time: 5:12:44 PM
 Duration: 00:00:14

Z Direction 20

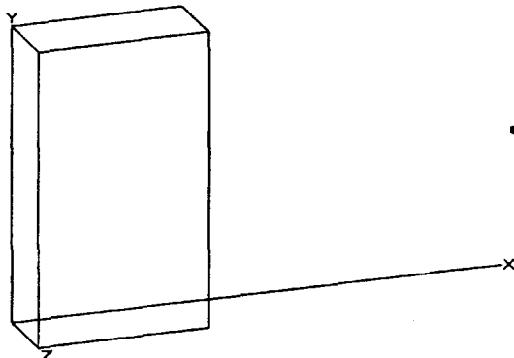
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			Fluence Rate MeV/cm ² /sec	Exposure Rate mR/hr	Exposure Rate mR/hr	
			No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.394e+04	2.713e-134	3.201e-30	2.327e-135	2.745e-31	
0.02	3.060e+06	8.993e-62	3.508e-28	3.115e-63	1.215e-29	
0.03	1.415e+11	1.065e-17	2.158e-17	1.056e-19	2.139e-19	
0.04	7.074e+10	1.232e-07	3.962e-07	5.449e-10	1.752e-09	
0.05	9.431e+09	1.453e-04	6.786e-04	3.870e-07	1.808e-06	
0.06	1.114e+08	1.217e-04	7.180e-04	2.417e-07	1.426e-06	
0.08	1.586e+09	6.865e-02	4.582e-01	1.086e-04	7.251e-04	
0.1	2.782e+10	5.395e+00	3.473e+01	8.253e-03	5.313e-02	
0.15	6.002e+07	5.014e-02	2.705e-01	8.257e-05	4.455e-04	
0.2	5.921e+09	9.389e+00	4.459e+01	1.657e-02	7.870e-02	
0.3	1.384e+10	4.560e+01	1.819e+02	8.651e-02	3.451e-01	
0.4	3.516e+09	1.871e+01	6.597e+01	3.645e-02	1.285e-01	
0.5	5.317e+08	4.074e+00	1.308e+01	7.997e-03	2.567e-02	
0.6	2.163e+12	2.229e+04	6.616e+04	4.350e+01	1.291e+02	
0.8	2.147e+10	3.532e+02	9.338e+02	6.718e-01	1.776e+00	
1.0	4.291e+10	1.017e+03	2.473e+03	1.874e+00	4.558e+00	
1.5	3.539e+10	1.627e+03	3.443e+03	2.737e+00	5.793e+00	
2.0	4.123e+02	3.009e-05	5.884e-05	4.653e-08	9.098e-08	
3.0	5.535e+03	7.600e-04	1.343e-03	1.031e-06	1.822e-06	
TOTALS:	2.538e+12	2.537e+04	7.335e+04	4.894e+01	1.419e+02	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTRU8.MS5
Run Date: June 13, 2001
Run Time: 5:15:34 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck8-WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-15ft--file:dumptru8
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

#	X	Y	Z
1	701.6496 cm 23 ft 0.2 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTRU8.MS5
 Run Date: June 13, 2001
 Run Time: 5:15:34 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTRU8.MS5
 Run Date: June 13, 2001
 Run Time: 5:15:34 PM
 Duration: 00:00:14

Z Direction

20

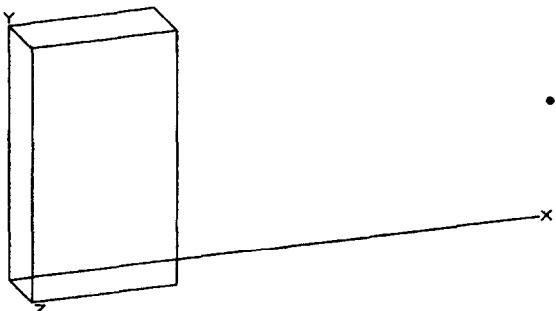
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			Fluence Rate		Exposure Rate	
			No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.394e+04	1.841e-134	1.510e-30	1.579e-135	1.295e-31	
0.02	3.060e+06	6.422e-62	1.655e-28	2.225e-63	5.731e-30	
0.03	1.415e+11	6.863e-18	1.390e-17	6.802e-20	1.378e-19	
0.04	7.074e+10	7.234e-08	2.322e-07	3.199e-10	1.027e-09	
0.05	9.431e+09	7.742e-05	3.596e-04	2.063e-07	9.579e-07	
0.06	1.114e+08	6.009e-05	3.510e-04	1.194e-07	6.973e-07	
0.08	1.586e+09	3.115e-02	2.053e-01	4.929e-05	3.249e-04	
0.1	2.782e+10	2.361e+00	1.505e+01	3.612e-03	2.302e-02	
0.15	6.002e+07	2.133e-02	1.149e-01	3.513e-05	1.892e-04	
0.2	5.921e+09	3.969e+00	1.889e+01	7.004e-03	3.334e-02	
0.3	1.384e+10	1.923e+01	7.707e+01	3.648e-02	1.462e-01	
0.4	3.516e+09	7.889e+00	2.798e+01	1.537e-02	5.452e-02	
0.5	5.317e+08	1.719e+00	5.553e+00	3.374e-03	1.090e-02	
0.6	2.163e+12	9.410e+03	2.812e+04	1.837e+01	5.488e+01	
0.8	2.147e+10	1.493e+02	3.976e+02	2.840e-01	7.562e-01	
1.0	4.291e+10	4.303e+02	1.054e+03	7.932e-01	1.943e+00	
1.5	3.539e+10	6.904e+02	1.473e+03	1.162e+00	2.478e+00	
2.0	4.123e+02	1.280e-05	2.524e-05	1.980e-08	3.903e-08	
3.0	5.535e+03	3.248e-04	5.785e-04	4.406e-07	7.849e-07	
TOTALS:	2.538e+12	1.071e+04	3.119e+04	2.067e+01	6.032e+01	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTRU9.MS5
Run Date: June 13, 2001
Run Time: 5:17:50 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck9-WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-21ft--file:dumptru9
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

#	X	Y	Z
1	884.5296 cm 29 ft 0.2 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTRU9.MS5
 Run Date: June 13, 2001
 Run Time: 5:17:50 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTRU9.MS5
 Run Date: June 13, 2001
 Run Time: 5:17:50 PM
 Duration: 00:00:14

Z Direction

20

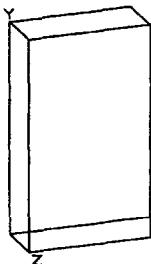
<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec	<u>Results</u>		
			<u>Fluence Rate</u> MeV/cm ² /sec	<u>Exposure Rate</u> mR/hr	<u>Exposure Rate</u> mR/hr
			<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>
0.015	4.394e+04	1.160e-134	8.743e-31	9.952e-136	7.499e-32
0.02	3.060e+06	4.408e-62	9.583e-29	1.527e-63	3.319e-30
0.03	1.415e+11	4.626e-18	9.369e-18	4.584e-20	9.285e-20
0.04	7.074e+10	4.483e-08	1.437e-07	1.983e-10	6.357e-10
0.05	9.431e+09	4.497e-05	2.083e-04	1.198e-07	5.549e-07
0.06	1.114e+08	3.362e-05	1.958e-04	6.677e-08	3.889e-07
0.08	1.586e+09	1.684e-02	1.110e-01	2.665e-05	1.756e-04
0.1	2.782e+10	1.261e+00	8.064e+00	1.929e-03	1.234e-02
0.15	6.002e+07	1.131e-02	6.147e-02	1.862e-05	1.012e-04
0.2	5.921e+09	2.103e+00	1.012e+01	3.711e-03	1.786e-02
0.3	1.384e+10	1.021e+01	4.139e+01	1.936e-02	7.852e-02
0.4	3.516e+09	4.195e+00	1.505e+01	8.174e-03	2.932e-02
0.5	5.317e+08	9.156e-01	2.990e+00	1.797e-03	5.869e-03
0.6	2.163e+12	5.019e+03	1.515e+04	9.797e+00	2.958e+01
0.8	2.147e+10	7.982e+01	2.146e+02	1.518e-01	4.082e-01
1.0	4.291e+10	2.305e+02	5.698e+02	4.248e-01	1.050e+00
1.5	3.539e+10	3.711e+02	7.983e+02	6.244e-01	1.343e+00
2.0	4.123e+02	6.901e-06	1.371e-05	1.067e-08	2.120e-08
3.0	5.535e+03	1.757e-04	3.153e-04	2.384e-07	4.277e-07
TOTALS:	2.538e+12	5.719e+03	1.681e+04	1.103e+01	3.252e+01

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR10.MS5
Run Date: June 13, 2001
Run Time: 5:19:56 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck10WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-27ft-file:dumptru10
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

#	X	Y	Z
1	1.07e+03 cm 35 ft 0.2 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR10.MS5
 Run Date: June 13, 2001
 Run Time: 5:19:56 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR10.MS5
 Run Date: June 13, 2001
 Run Time: 5:19:56 PM
 Duration: 00:00:14

Z Direction

20

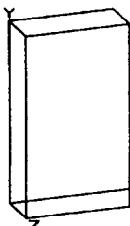
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Results</u>		
			<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
			<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>
0.015	4.394e+04	7.145e-135	5.693e-31	6.128e-136	4.883e-32
0.02	3.060e+06	3.072e-62	6.240e-29	1.064e-63	2.161e-30
0.03	1.415e+11	3.192e-18	6.464e-18	3.163e-20	6.406e-20
0.04	7.074e+10	2.915e-08	9.341e-08	1.289e-10	4.131e-10
0.05	9.431e+09	2.826e-05	1.309e-04	7.529e-08	3.486e-07
0.06	1.114e+08	2.076e-05	1.210e-04	4.124e-08	2.404e-07
0.08	1.586e+09	1.026e-02	6.786e-02	1.623e-05	1.074e-04
0.1	2.782e+10	7.646e-01	4.927e+00	1.170e-03	7.538e-03
0.15	6.002e+07	6.849e-03	3.769e-02	1.128e-05	6.207e-05
0.2	5.921e+09	1.275e+00	6.222e+00	2.251e-03	1.098e-02
0.3	1.384e+10	6.208e+00	2.551e+01	1.178e-02	4.839e-02
0.4	3.516e+09	2.558e+00	9.287e+00	4.983e-03	1.810e-02
0.5	5.317e+08	5.592e-01	1.847e+00	1.098e-03	3.626e-03
0.6	2.163e+12	3.070e+03	9.369e+03	5.993e+00	1.829e+01
0.8	2.147e+10	4.895e+01	1.329e+02	9.310e-02	2.528e-01
1.0	4.291e+10	1.416e+02	3.532e+02	2.610e-01	6.511e-01
1.5	3.539e+10	2.288e+02	4.959e+02	3.849e-01	8.343e-01
2.0	4.123e+02	4.264e-06	8.529e-06	6.594e-09	1.319e-08
3.0	5.535e+03	1.089e-04	1.967e-04	1.478e-07	2.668e-07
TOTALS:	2.538e+12	3.501e+03	1.040e+04	6.753e+00	2.011e+01

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR11.MS5
Run Date: June 13, 2001
Run Time: 5:21:50 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck11WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-33ft-file:dumptrull
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

X	Y	Z
# 1 1.25e+03 cm	213.36 cm	53.34 cm
41 ft 0.2 in	7 ft 0.0 in	1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR11.MS5
 Run Date: June 13, 2001
 Run Time: 5:21:50 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR11.MS5
 Run Date: June 13, 2001
 Run Time: 5:21:50 PM
 Duration: 00:00:14

Z Direction 20

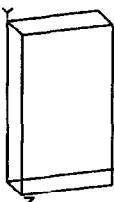
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	Results		Exposure Rate mR/hr	Exposure Rate mR/hr
			No Buildup	With Buildup		
			Fluence Rate MeV/cm ² /sec	No Buildup		
0.015	4.394e+04	4.410e-135	3.999e-31	3.782e-136	3.430e-32	
0.02	3.060e+06	2.175e-62	4.383e-29	7.532e-64	1.518e-30	
0.03	1.415e+11	2.248e-18	4.553e-18	2.228e-20	4.513e-20	
0.04	7.074e+10	1.985e-08	6.363e-08	8.781e-11	2.814e-10	
0.05	9.431e+09	1.893e-05	8.771e-05	5.043e-08	2.337e-07	
0.06	1.114e+08	1.380e-05	8.058e-05	2.741e-08	1.601e-07	
0.08	1.586e+09	6.776e-03	4.509e-02	1.072e-05	7.135e-05	
0.1	2.782e+10	5.046e-01	3.282e+00	7.719e-04	5.020e-03	
0.15	6.002e+07	4.525e-03	2.524e-02	7.451e-06	4.156e-05	
0.2	5.921e+09	8.442e-01	4.177e+00	1.490e-03	7.373e-03	
0.3	1.384e+10	4.124e+00	1.717e+01	7.822e-03	3.257e-02	
0.4	3.516e+09	1.703e+00	6.260e+00	3.318e-03	1.220e-02	
0.5	5.317e+08	3.731e-01	1.246e+00	7.323e-04	2.446e-03	
0.6	2.163e+12	2.051e+03	6.325e+03	4.004e+00	1.235e+01	
0.8	2.147e+10	3.278e+01	8.983e+01	6.235e-02	1.709e-01	
1.0	4.291e+10	9.500e+01	2.390e+02	1.751e-01	4.406e-01	
1.5	3.539e+10	1.540e+02	3.362e+02	2.591e-01	5.656e-01	
2.0	4.123e+02	2.877e-06	5.789e-06	4.449e-09	8.953e-09	
3.0	5.535e+03	7.371e-05	1.338e-04	1.000e-07	1.815e-07	
TOTALS:	2.538e+12	2.341e+03	7.023e+03	4.515e+00	1.358e+01	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR12.MS5
Run Date: June 13, 2001
Run Time: 5:23:58 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck12WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-39ft-file:dumptru12
Geometry: 13 - Rectangular Volume



Source Dimensions
Length 243.84 cm 8 ft
Width 106.68 cm 3 ft 6.0 in
Height 426.72 cm 14 ft 0.0 in

Dose Points
X Y Z
1 1.43e+03 cm 213.36 cm 53.34 cm
47 ft 0.2 in 7 ft 0.0 in 1 ft 9.0 in

Shields
Shield Name Dimension Material Density
Source 1.11e+07 cm³ Concrete 1.5
Shield 1 .635 cm Iron 7.86
Air Gap Air 0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR12.MS5
 Run Date: June 13, 2001
 Run Time: 5:23:58 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR12.MS5
 Run Date: June 13, 2001
 Run Time: 5:23:58 PM
 Duration: 00:00:14

Z Direction

20

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	Results			
			<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>	
			<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.394e+04	2.745e-135	2.962e-31	2.354e-136	2.541e-32	
0.02	3.060e+06	1.553e-62	3.247e-29	5.379e-64	1.125e-30	
0.03	1.415e+11	1.619e-18	3.280e-18	1.605e-20	3.251e-20	
0.04	7.074e+10	1.408e-08	4.513e-08	6.226e-11	1.996e-10	
0.05	9.431e+09	1.332e-05	6.180e-05	3.549e-08	1.646e-07	
0.06	1.114e+08	9.679e-06	5.668e-05	1.922e-08	1.126e-07	
0.08	1.586e+09	4.745e-03	3.178e-02	7.508e-06	5.028e-05	
0.1	2.782e+10	3.534e-01	2.321e+00	5.406e-04	3.551e-03	
0.15	6.002e+07	3.176e-03	1.796e-02	5.230e-06	2.957e-05	
0.2	5.921e+09	5.939e-01	2.981e+00	1.048e-03	5.261e-03	
0.3	1.384e+10	2.911e+00	1.228e+01	5.522e-03	2.330e-02	
0.4	3.516e+09	1.205e+00	4.485e+00	2.348e-03	8.738e-03	
0.5	5.317e+08	2.645e-01	8.935e-01	5.193e-04	1.754e-03	
0.6	2.163e+12	1.457e+03	4.538e+03	2.844e+00	8.858e+00	
0.8	2.147e+10	2.334e+01	6.452e+01	4.439e-02	1.227e-01	
1.0	4.291e+10	6.775e+01	1.718e+02	1.249e-01	3.167e-01	
1.5	3.539e+10	1.102e+02	2.421e+02	1.854e-01	4.073e-01	
2.0	4.123e+02	2.062e-06	4.174e-06	3.189e-09	6.454e-09	
3.0	5.535e+03	5.299e-05	9.661e-05	7.189e-08	1.311e-07	
TOTALS:	2.538e+12	1.664e+03	5.040e+03	3.208e+00	9.748e+00	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR13.MS5
Run Date: June 13, 2001
Run Time: 5:25:54 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck13WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-45ft-file:dumptru13
Geometry: 13 - Rectangular Volume



Source Dimensions
Length 243.84 cm 8 ft
Width 106.68 cm 3 ft 6.0 in
Height 426.72 cm 14 ft 0.0 in

Dose Points
X Y Z
1 1.62e+03 cm 213.36 cm 53.34 cm
53 ft 0.2 in 7 ft 0.0 in 1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR13.MS5
 Run Date: June 13, 2001
 Run Time: 5:25:54 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR13.MS5
 Run Date: June 13, 2001
 Run Time: 5:25:54 PM
 Duration: 00:00:14

Z Direction 20

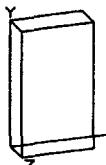
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			No Buildup	With Buildup		
			MeV/cm ² /sec	MeV/cm ² /sec		
0.015	4.394e+04	1.721e-135	2.282e-31	1.476e-136	1.957e-32	
0.02	3.060e+06	1.116e-62	2.501e-29	3.866e-64	8.664e-31	
0.03	1.415e+11	1.192e-18	2.415e-18	1.181e-20	2.393e-20	
0.04	7.074e+10	1.032e-08	3.310e-08	4.564e-11	1.464e-10	
0.05	9.431e+09	9.743e-06	4.527e-05	2.595e-08	1.206e-07	
0.06	1.114e+08	7.073e-06	4.155e-05	1.405e-08	8.253e-08	
0.08	1.586e+09	3.468e-03	2.339e-02	5.488e-06	3.701e-05	
0.1	2.782e+10	2.586e-01	1.715e+00	3.956e-04	2.624e-03	
0.15	6.002e+07	2.331e-03	1.336e-02	3.838e-06	2.200e-05	
0.2	5.921e+09	4.369e-01	2.224e+00	7.711e-04	3.925e-03	
0.3	1.384e+10	2.149e+00	9.188e+00	4.077e-03	1.743e-02	
0.4	3.516e+09	8.919e-01	3.359e+00	1.738e-03	6.544e-03	
0.5	5.317e+08	1.962e-01	6.697e-01	3.850e-04	1.315e-03	
0.6	2.163e+12	1.082e+03	3.404e+03	2.112e+00	6.644e+00	
0.8	2.147e+10	1.737e+01	4.844e+01	3.304e-02	9.214e-02	
1.0	4.291e+10	5.052e+01	1.291e+02	9.312e-02	2.380e-01	
1.5	3.539e+10	8.239e+01	1.822e+02	1.386e-01	3.065e-01	
2.0	4.123e+02	1.545e-06	3.144e-06	2.390e-09	4.862e-09	
3.0	5.535e+03	3.981e-05	7.289e-05	5.401e-08	9.889e-08	
TOTALS:	2.538e+12	1.236e+03	3.781e+03	2.384e+00	7.313e+00	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR14.MS5
Run Date: June 13, 2001
Run Time: 5:28:29 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck14WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-51ft-file:dumptru14
Geometry: 13 - Rectangular Volume



Source Dimensions
Length 243.84 cm 8 ft
Width 106.68 cm 3 ft 6.0 in
Height 426.72 cm 14 ft 0.0 in

Dose Points
1 1.80e+03 cm 213.36 cm 53.34 cm
59 ft 0.2 in 7 ft 0.0 in 1 ft 9.0 in

Shields
Shield Name Dimension Material Density
Source 1.11e+07 cm³ Concrete 1.5
Shield 1 .635 cm Iron 7.86
Air Gap Air 0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR14.MS5
 Run Date: June 13, 2001
 Run Time: 5:28:29 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR14.MS5
 Run Date: June 13, 2001
 Run Time: 5:28:29 PM
 Duration: 00:00:14

Z Direction

20

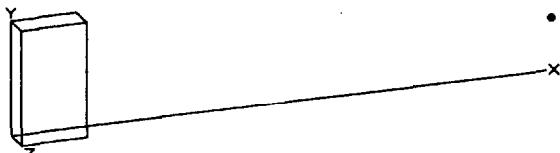
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			<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
			<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>
0.015	4.394e+04	1.085e-135	1.812e-31	9.308e-137	1.554e-32
0.02	3.060e+06	8.072e-63	1.986e-29	2.796e-64	6.878e-31
0.03	1.415e+11	8.953e-19	1.813e-18	8.873e-21	1.797e-20
0.04	7.074e+10	7.774e-09	2.495e-08	3.438e-11	1.103e-10
0.05	9.431e+09	7.345e-06	3.419e-05	1.957e-08	9.107e-08
0.06	1.114e+08	5.336e-06	3.145e-05	1.060e-08	6.247e-08
0.08	1.586e+09	2.621e-03	1.779e-02	4.147e-06	2.816e-05
0.1	2.782e+10	1.957e-01	1.311e+00	2.994e-04	2.006e-03
0.15	6.002e+07	1.769e-03	1.028e-02	2.913e-06	1.692e-05
0.2	5.921e+09	3.324e-01	1.716e+00	5.867e-04	3.029e-03
0.3	1.384e+10	1.641e+00	7.109e+00	3.113e-03	1.348e-02
0.4	3.516e+09	6.829e-01	2.602e+00	1.331e-03	5.070e-03
0.5	5.317e+08	1.505e-01	5.192e-01	2.953e-04	1.019e-03
0.6	2.163e+12	8.312e+02	2.641e+03	1.622e+00	5.155e+00
0.8	2.147e+10	1.338e+01	3.762e+01	2.544e-02	7.155e-02
1.0	4.291e+10	3.897e+01	1.004e+02	7.183e-02	1.850e-01
1.5	3.539e+10	6.374e+01	1.418e+02	1.072e-01	2.385e-01
2.0	4.123e+02	1.198e-06	2.449e-06	1.852e-09	3.788e-09
3.0	5.535e+03	3.093e-05	5.687e-05	4.196e-08	7.715e-08
TOTALS:	2.538e+12	9.503e+02	2.934e+03	1.833e+00	5.674e+00

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR15.MS5
Run Date: June 13, 2001
Run Time: 5:30:07 PM
Duration: 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck15WorstCase
Description: 15yd3 Dump Truck--Worst Case-.25FeShield-57ft-file:dumptru15
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	243.84 cm	8 ft
Width	106.68 cm	3 ft 6.0 in
Height	426.72 cm	14 ft 0.0 in

Dose Points

	X	Y	Z
# 1	1.98e+03 cm 65 ft 0.2 in	213.36 cm 7 ft 0.0 in	53.34 cm 1 ft 9.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	.635 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm³</u>
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

DOS File: DUMPTR15.MS5
 Run Date: June 13, 2001
 Run Time: 5:30:07 PM
 Duration: 00:00:14

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20

DOS File: DUMPTR15.MS5
 Run Date: June 13, 2001
 Run Time: 5:30:07 PM
 Duration: 00:00:14

Z Direction 20

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	Results		Exposure Rate mR/hr With Buildup	Exposure Rate mR/hr With Buildup
			Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup		
0.015	4.394e+04	6.866e-136	1.473e-31	5.889e-137	1.264e-32	
0.02	3.060e+06	5.877e-63	1.615e-29	2.036e-64	5.593e-31	
0.03	1.415e+11	6.844e-19	1.386e-18	6.782e-21	1.374e-20	
0.04	7.074e+10	5.989e-09	1.924e-08	2.649e-11	8.507e-11	
0.05	9.431e+09	5.675e-06	2.646e-05	1.512e-08	7.049e-08	
0.06	1.114e+08	4.130e-06	2.442e-05	8.203e-09	4.851e-08	
0.08	1.586e+09	2.033e-03	1.390e-02	3.216e-06	2.200e-05	
0.1	2.782e+10	1.520e-01	1.029e+00	2.326e-04	1.575e-03	
0.15	6.002e+07	1.379e-03	8.121e-03	2.271e-06	1.337e-05	
0.2	5.921e+09	2.598e-01	1.360e+00	4.585e-04	2.400e-03	
0.3	1.384e+10	1.287e+00	5.648e+00	2.442e-03	1.071e-02	
0.4	3.516e+09	5.370e-01	2.070e+00	1.046e-03	4.033e-03	
0.5	5.317e+08	1.185e-01	4.134e-01	2.327e-04	8.114e-04	
0.6	2.163e+12	6.558e+02	2.104e+03	1.280e+00	4.106e+00	
0.8	2.147e+10	1.058e+01	3.000e+01	2.012e-02	5.705e-02	
1.0	4.291e+10	3.087e+01	8.008e+01	5.690e-02	1.476e-01	
1.5	3.539e+10	5.064e+01	1.133e+02	8.520e-02	1.906e-01	
2.0	4.123e+02	9.533e-07	1.959e-06	1.474e-09	3.029e-09	
3.0	5.535e+03	2.467e-05	4.554e-05	3.347e-08	6.179e-08	
TOTALS:	2.538e+12	7.502e+02	2.338e+03	1.447e+00	4.521e+00	

Appendix D

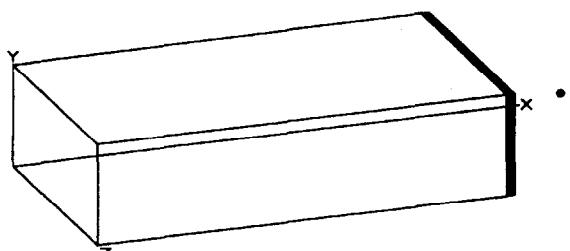
MicroShield Analysis for Exposure Rate for Iron Thickness Varied versus Exposure Rate to Dump Truck Driver

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR17.MS5
Run Date: June 13, 2001
Run Time: 10:28:37 PM
Duration: 00:00:15

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck17WorstCase
Description: 15yd3 Dump Truck-WorstCase-3.5inFeShield--1m--file:dumptru17
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	426.72 cm	14 ft 0.0 in
Width	243.84 cm	8 ft
Height	106.68 cm	3 ft 6.0 in

Dose Points

#	X	Y	Z
1	526.9992 cm 17 ft 3.5 in	53.34 cm 1 ft 9.0 in	121.92 cm 4 ft

Shields

Shield Name	Dimension	Material	Density
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	8.89 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

Page : 4
DOS File: DUMPTR17.MS5
Run Date: June 13, 2001
Run Time: 10:28:37 PM
Duration: 00:00:15

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Shield 1

Integration Parameters

X Direction	20
Y Direction	20

Page : 3
DOS File: DUMPTR17.MS5
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Z Direction

20

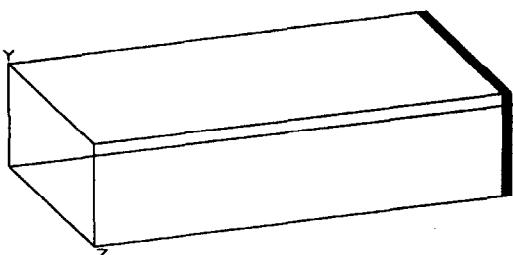
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	Results			
			Fluence Rate MeV/cm ² /sec	Exposure Rate mR/hr	Exposure Rate mR/hr	
			No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.394e+04	0.000e+00	7.355e-30	0.000e+00	6.309e-31	
0.02	3.060e+06	0.000e+00	8.052e-28	0.000e+00	2.789e-29	
0.03	1.415e+11	2.214e-242	5.111e-23	2.194e-244	5.066e-25	
0.04	7.074e+10	1.578e-106	3.908e-23	6.980e-109	1.728e-25	
0.05	9.431e+09	1.565e-57	7.451e-24	4.169e-60	1.985e-26	
0.06	1.114e+08	4.210e-37	1.285e-25	8.362e-40	2.553e-28	
0.08	1.586e+09	8.771e-18	2.275e-17	1.388e-20	3.599e-20	
0.1	2.782e+10	7.445e-10	2.720e-09	1.139e-12	4.161e-12	
0.15	6.002e+07	3.436e-07	2.270e-06	5.658e-10	3.738e-09	
0.2	5.921e+09	1.394e-03	1.400e-02	2.461e-06	2.471e-05	
0.3	1.384e+10	6.263e-02	8.154e-01	1.188e-04	1.547e-03	
0.4	3.516e+09	7.071e-02	9.459e-01	1.378e-04	1.843e-03	
0.5	5.317e+08	2.946e-02	3.677e-01	5.783e-05	7.218e-04	
0.6	2.163e+12	2.594e+02	2.929e+03	5.063e-01	5.716e+00	
0.8	2.147e+10	8.185e+00	7.532e+01	1.557e-02	1.433e-01	
1.0	4.291e+10	3.850e+01	2.952e+02	7.097e-02	5.441e-01	
1.5	3.539e+10	1.352e+02	7.431e+02	2.274e-01	1.250e+00	
2.0	4.123e+02	3.883e-06	1.748e-05	6.005e-09	2.703e-08	
3.0	5.535e+03	1.552e-04	5.423e-04	2.105e-07	7.357e-07	
TOTALS:	2.538e+12	4.414e+02	4.044e+03	8.206e-01	7.658e+00	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

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DOS File: DUMPTR18.MS5
Run Date: June 13, 2001
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File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck18WorstCase
Description: 15yd3 DumpTruck-WorstCase-3.75inFeShield--1m--file:dumptru18
Geometry: 13 - Rectangular Volume



Source Dimensions
Length 426.72 cm 14 ft 0.0 in
Width 243.84 cm 8 ft
Height 106.68 cm 3 ft 6.0 in

Dose Points
1 X Y Z
 527.6088 cm 53.34 cm 121.92 cm
 17 ft 3.7 in 1 ft 9.0 in 4 ft

Shields
Shield Name Dimension Material Density
Source 1.11e+07 cm³ Concrete 1.5
Shield 1 9.525 cm Iron 7.86
Air Gap Air 0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
 The material reference is : Shield 1

Integration Parameters	
X Direction	20
Y Direction	20

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 DOS File: DUMPTR18.MS5
 Run Date: June 13, 2001
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 Duration: 00:00:15

Z Direction

20

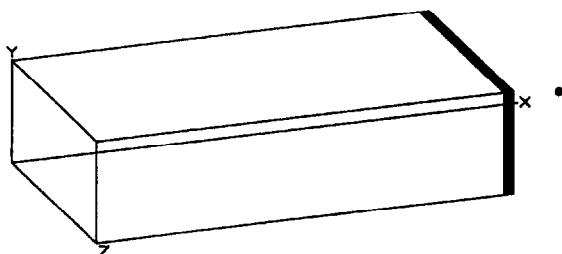
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	Results			
			Fluence Rate MeV/cm ² /sec	Exposure Rate mR/hr	Exposure Rate mR/hr	
			No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.394e+04	0.000e+00	7.313e-30	0.000e+00	6.273e-31	
0.02	3.060e+06	0.000e+00	8.006e-28	0.000e+00	2.773e-29	
0.03	1.415e+11	1.333e-259	5.082e-23	1.321e-261	5.036e-25	
0.04	7.074e+10	4.262e-114	3.886e-23	1.885e-116	1.719e-25	
0.05	9.431e+09	1.400e-61	7.408e-24	3.731e-64	1.974e-26	
0.06	1.114e+08	1.391e-39	1.278e-25	2.764e-42	2.538e-28	
0.08	1.586e+09	5.251e-19	1.374e-18	8.310e-22	2.174e-21	
0.1	2.782e+10	1.266e-10	4.737e-10	1.937e-13	7.246e-13	
0.15	6.002e+07	1.306e-07	8.999e-07	2.151e-10	1.482e-09	
0.2	5.921e+09	6.652e-04	7.083e-03	1.174e-06	1.250e-05	
0.3	1.384e+10	3.519e-02	4.924e-01	6.676e-05	9.341e-04	
0.4	3.516e+09	4.280e-02	6.184e-01	8.340e-05	1.205e-03	
0.5	5.317e+08	1.870e-02	2.520e-01	3.671e-05	4.947e-04	
0.6	2.163e+12	1.706e+02	2.074e+03	3.329e-01	4.049e+00	
0.8	2.147e+10	5.661e+00	5.583e+01	1.077e-02	1.062e-01	
1.0	4.291e+10	2.761e+01	2.256e+02	5.090e-02	4.159e-01	
1.5	3.539e+10	1.028e+02	5.961e+02	1.729e-01	1.003e+00	
2.0	4.123e+02	3.050e-06	1.440e-05	4.717e-09	2.227e-08	
3.0	5.535e+03	1.262e-04	4.592e-04	1.712e-07	6.230e-07	
TOTALS:	2.538e+12	3.067e+02	2.953e+03	5.676e-01	5.576e+00	

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: DUMPTR16.MS5
Run Date: June 13, 2001
Run Time: 10:23:28 PM
Duration: 00:00:15

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DumpTruck16WorstCase
Description: 15yd3 Dump Truck-Worst Case-4in FeShield--1m--file:dumptr16
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	426.72 cm	14 ft 0.0 in
Width	243.84 cm	8 ft
Height	106.68 cm	3 ft 6.0 in

Dose Points

#	X	Y	Z
1	528.2184 cm 17 ft 4.0 in	53.34 cm 1 ft 9.0 in	121.92 cm 4 ft

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	1.11e+07 cm ³	Concrete	1.5
Shield 1	10.16 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	3.1650e-003	1.1711e+008	2.8513e-004	1.0550e+001
Am-242	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-242m	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Am-243	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Ba-137m	6.4810e+001	2.3980e+012	5.8387e+000	2.1603e+005
Bi-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
C-14	3.4990e-008	1.2946e+003	3.1522e-009	1.1663e-004
Cd-113m	1.2330e-003	4.5621e+007	1.1108e-004	4.1099e+000
Ce-144	1.4660e-002	5.4242e+008	1.3207e-003	4.8866e+001
Cm-244	1.3660e-006	5.0542e+004	1.2306e-007	4.5532e-003
Co-57	5.9640e-006	2.2067e+005	5.3729e-007	1.9880e-002
Co-60	3.1650e-001	1.1711e+010	2.8513e-002	1.0550e+003
Cs-134	1.6560e-002	6.1272e+008	1.4919e-003	5.5199e+001
Cs-135	2.6660e-005	9.8642e+005	2.4018e-006	8.8865e-002
Cs-137	6.8510e+001	2.5349e+012	6.1720e+000	2.2836e+005
Eu-152	1.3830e+000	5.1171e+010	1.2459e-001	4.6099e+003
Eu-154	8.1630e-001	3.0203e+010	7.3539e-002	2.7210e+003
Eu-155	1.3700e-001	5.0690e+009	1.2342e-002	4.5666e+002
H-3	6.1640e-003	2.2807e+008	5.5531e-004	2.0546e+001
I-129	6.1640e-005	2.2807e+006	5.5531e-006	2.0546e-001
K-40	5.6140e-004	2.0772e+007	5.0576e-005	1.8713e+000
Kr-85	8.8300e-001	3.2671e+010	7.9548e-002	2.9433e+003
Nb-93m	1.0160e-005	3.7592e+005	9.1530e-007	3.3866e-002
Np-237	9.1630e-005	3.3903e+006	8.2548e-006	3.0543e-001

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Np-239	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Pa-231	5.3310e-008	1.9725e+003	4.8026e-009	1.7770e-004
Pa-233	3.3320e-005	1.2328e+006	3.0017e-006	1.1106e-001
Pa-234m	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Pb-209	3.6650e-011	1.3561e+000	3.3017e-012	1.2216e-007
Pb-212	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pd-107	4.6650e-006	1.7261e+005	4.2026e-007	1.5550e-002
Pm-146	4.3320e-006	1.6028e+005	3.9026e-007	1.4440e-002
Pm-147	2.8320e-001	1.0478e+010	2.5513e-002	9.4398e+002
Po-212	2.4990e-007	9.2463e+003	2.2513e-008	8.3298e-004
Po-216	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Pr-144	1.3330e-006	4.9321e+004	1.2009e-007	4.4433e-003
Pr-144m	1.9990e-008	7.3963e+002	1.8009e-009	6.6632e-005
Pu-238	1.2670e-001	4.6879e+009	1.1414e-002	4.2233e+002
Pu-239	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-240	5.3980e-003	1.9973e+008	4.8630e-004	1.7993e+001
Pu-241	4.8310e-002	1.7875e+009	4.3522e-003	1.6103e+002
Pu-242	1.8330e-007	6.7821e+003	1.6513e-008	6.1099e-004
Ra-224	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ra-226	7.4970e-004	2.7739e+007	6.7539e-005	2.4990e+000
Rh-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Rn-220	4.1650e-007	1.5411e+004	3.7522e-008	1.3883e-003
Ru-106	8.6630e-006	3.2053e+005	7.8044e-007	2.8876e-002
Sb-125	6.9970e-003	2.5889e+008	6.3035e-004	2.3323e+001
Sb-126	1.5660e-005	5.7942e+005	1.4108e-006	5.2199e-002
Sb-126m	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Se-79	1.2500e-004	4.6250e+006	1.1261e-005	4.1666e-001
Sm-151	2.4990e-001	9.2463e+009	2.2513e-002	8.3298e+002
Sn-126	1.1160e-004	4.1292e+006	1.0054e-005	3.7199e-001
Sr-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Tc-99	4.3320e-003	1.6028e+008	3.9026e-004	1.4440e+001
Te-125m	1.6660e-003	6.1642e+007	1.5009e-004	5.5532e+000
Th-228	4.8310e-006	1.7875e+005	4.3522e-007	1.6103e-002
Th-230	5.8310e-005	2.1575e+006	5.2531e-006	1.9436e-001
Th-231	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
Th-232	3.5320e-005	1.3068e+006	3.1819e-006	1.1773e-001
Th-234	1.2990e-006	4.8063e+004	1.1702e-007	4.3299e-003
Tl-208	1.4990e-007	5.5463e+003	1.3504e-008	4.9966e-004
U-232	3.9980e-007	1.4793e+004	3.6017e-008	1.3326e-003
U-233	1.7330e-005	6.4121e+005	1.5612e-006	5.7766e-002
U-234	4.4980e-003	1.6643e+008	4.0522e-004	1.4993e+001
U-235	1.2160e-004	4.4992e+006	1.0955e-005	4.0533e-001
U-236	1.5330e-004	5.6721e+006	1.3811e-005	5.1099e-001
U-238	8.6800e-004	3.2116e+007	7.8197e-005	2.8933e+000
Y-90	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004
Zn-65	1.6660e-012	6.1642e-002	1.5009e-013	5.5532e-009
Zr-93	1.6660e+001	6.1642e+011	1.5009e+000	5.5532e+004

Buildup
The material reference is : Shield 1

Integration Parameters

X Direction	20
Y Direction	20

Page : 3
DOS File: DUMPTR16.MS5
Run Date: June 13, 2001
Run Time: 10:23:28 PM
Duration: 00:00:15

Z Direction

20

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	Results			
			Fluence Rate MeV/cm ² /sec	Exposure Rate mR/hr	Exposure Rate mR/hr	
			No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.394e+04	0.000e+00	7.271e-30	0.000e+00	6.237e-31	
0.02	3.060e+06	0.000e+00	7.960e-28	0.000e+00	2.757e-29	
0.03	1.415e+11	8.066e-277	5.053e-23	7.994e-279	5.008e-25	
0.04	7.074e+10	1.156e-121	3.863e-23	5.111e-124	1.709e-25	
0.05	9.431e+09	1.259e-65	7.366e-24	3.354e-68	1.962e-26	
0.06	1.114e+08	4.618e-42	1.270e-25	9.173e-45	2.523e-28	
0.08	1.586e+09	3.157e-20	8.311e-20	4.996e-23	1.315e-22	
0.1	2.782e+10	2.161e-11	8.265e-11	3.307e-14	1.265e-13	
0.15	6.002e+07	4.981e-08	3.569e-07	8.202e-11	5.877e-10	
0.2	5.921e+09	3.181e-04	3.580e-03	5.614e-07	6.319e-06	
0.3	1.384e+10	1.981e-02	2.969e-01	3.758e-05	5.633e-04	
0.4	3.516e+09	2.595e-02	4.037e-01	5.057e-05	7.866e-04	
0.5	5.317e+08	1.189e-02	1.724e-01	2.334e-05	3.385e-04	
0.6	2.163e+12	1.123e+02	1.467e+03	2.192e-01	2.863e+00	
0.8	2.147e+10	3.920e+00	4.132e+01	7.457e-03	7.858e-02	
1.0	4.291e+10	1.982e+01	1.722e+02	3.654e-02	3.174e-01	
1.5	3.539e+10	7.819e+01	4.776e+02	1.315e-01	8.036e-01	
2.0	4.123e+02	2.398e-06	1.186e-05	3.709e-09	1.834e-08	
3.0	5.535e+03	1.027e-04	3.886e-04	1.393e-07	5.273e-07	
TOTALS:	2.538e+12	2.143e+02	2.159e+03	3.948e-01	4.064e+00	

Appendix E

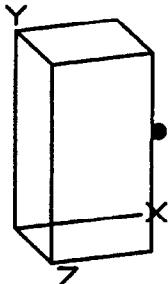
MicroShield Analysis for Exposure Rate from Unshielded Box Containing CPP-92, CPP-98, and CPP-99 Waste Stream Soil

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: 929899A2.MS5
Run Date: July 9, 2001
Run Time: 8:30:35 AM
Duration: 00:01:12

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: CP92,98,99BoxNoShield
Description: CPP92,98,99-4x4x8Box-NoShield-VariousDistances-file:92989A2
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	121.92 cm	4 ft
Width	121.92 cm	4 ft
Height	243.84 cm	8 ft

Dose Points

#	X	Y	Z
1	1.52e+02 cm 4 ft 11.8 in	121.92 cm 4 ft	60.96 cm 2 ft

Shields

Shield Name	Dimension	Material	Density
Source	128.0 ft ³	Concrete	1.5
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	1.2680e-004	4.6916e+006	3.4984e-005	1.2944e+000
Ba-137m	1.6320e-002	6.0384e+008	4.5026e-003	1.6660e+002
Cd-113m	1.1420e-006	4.2254e+004	3.1507e-007	1.1658e-002
Co-60	8.1590e-006	3.0188e+005	2.2510e-006	8.3288e-002
Cs-134	1.0880e-006	4.0256e+004	3.0017e-007	1.1106e-002
Cs-135	2.5020e-008	9.2574e+002	6.9029e-009	2.5541e-004
Cs-137	3.5520e-002	1.3142e+009	9.7998e-003	3.6259e+002
Eu-152	9.2460e-008	3.4210e+003	2.5509e-008	9.4385e-004
Eu-154	4.2970e-005	1.5899e+006	1.1855e-005	4.3864e-001
Eu-155	2.6110e-005	9.6607e+005	7.2036e-006	2.6653e-001
H-3	3.4810e-005	1.2880e+006	9.6039e-006	3.5535e-001
I-129	1.6860e-005	6.2382e+005	4.6516e-006	1.7211e-001
Kr-85	7.8330e-004	2.8982e+007	2.1611e-004	7.9960e+000
Nb-93m	9.2460e-009	3.4210e+002	2.5509e-009	9.4385e-005
Np-237	8.1590e-007	3.0188e+004	2.2510e-007	8.3288e-003
Pa-233	3.0460e-008	1.1270e+003	8.4038e-009	3.1094e-004
Pm-147	2.6650e-004	9.8605e+006	7.3526e-005	2.7205e+000
Pu-238	1.3270e-003	4.9099e+007	3.6611e-004	1.3546e+001
Pu-239	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-240	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-241	4.4600e-005	1.6502e+006	1.2305e-005	4.5528e-001
Rh-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Ru-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Sb-125	1.1420e-005	4.2254e+005	3.1507e-006	1.1658e-001
Sb-126	1.4690e-008	5.4353e+002	4.0529e-009	1.4996e-004

Page : 2
 DOS File: 929899A2.MS5
 Run Date: July 9, 2001
 Run Time: 8:30:35 AM
 Duration: 00:01:12

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Sb-126m	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Se-79	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
Sm-151	2.3390e-004	8.6543e+006	6.4532e-005	2.3877e+000
Sn-126	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Sr-90	4.9170e-002	1.8193e+009	1.3566e-002	5.0193e+002
Tc-99	4.0250e-006	1.4893e+005	1.1105e-006	4.1088e-002
Te-125m	1.5770e-006	5.8349e+004	4.3509e-007	1.6098e-002
Th-231	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
U-234	2.7740e-005	1.0264e+006	7.6534e-006	2.8317e-001
U-235	1.2510e-006	4.6287e+004	3.4515e-007	1.2770e-002
U-236	1.4140e-007	5.2318e+003	3.9012e-008	1.4434e-003
Y-90	1.5770e-002	5.8349e+008	4.3509e-003	1.6098e+002
Zr-93	5.9830e-007	2.2137e+004	1.6507e-007	6.1075e-003

Buildup
 The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20
Z Direction	20

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec	<u>Results</u>			
			<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>	<u>mR/hr</u>
			<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.023e+01	8.817e-11	9.366e-11	7.563e-12	8.034e-12	
0.02	2.861e+03	2.987e-07	3.312e-07	1.035e-08	1.147e-08	
0.03	3.639e+07	5.237e-02	6.463e-02	5.190e-04	6.405e-04	
0.04	8.962e+06	3.797e-02	5.421e-02	1.679e-04	2.398e-04	
0.05	1.435e+05	1.191e-03	1.978e-03	3.173e-06	5.269e-06	
0.06	1.729e+06	2.285e-02	4.592e-02	4.539e-05	9.122e-05	
0.08	3.073e+05	7.405e-03	1.842e-02	1.172e-05	2.915e-05	
0.1	8.546e+05	3.018e-02	8.410e-02	4.618e-05	1.287e-04	
0.15	8.724e+03	5.610e-04	1.681e-03	9.238e-07	2.769e-06	
0.2	1.696e+05	1.622e-02	4.791e-02	2.864e-05	8.456e-05	
0.3	3.306e+03	5.505e-04	1.512e-03	1.044e-06	2.869e-06	
0.4	1.476e+05	3.657e-02	9.372e-02	7.125e-05	1.826e-04	
0.5	1.736e+05	5.876e-02	1.422e-01	1.153e-04	2.792e-04	
0.6	5.437e+08	2.379e+02	5.474e+02	4.644e-01	1.068e+00	
0.8	6.589e+05	4.351e-01	9.274e-01	8.275e-04	1.764e-03	
1.0	7.938e+05	7.244e-01	1.460e+00	1.335e-03	2.691e-03	
1.5	9.243e+05	1.530e+00	2.796e+00	2.575e-03	4.704e-03	
TOTALS:	5.949e+08	2.409e+02	5.531e+02	4.702e-01	1.079e+00	
	Sensitivity	Variable	X Dose Point 1	(1 of 5)	(7 ft)	
0.015	4.023e+01	6.704e-11	7.116e-11	5.750e-12	6.104e-12	
0.02	2.861e+03	1.899e-07	2.096e-07	6.579e-09	7.259e-09	
0.03	3.639e+07	2.411e-02	2.929e-02	2.389e-04	2.902e-04	
0.04	8.962e+06	1.629e-02	2.299e-02	7.205e-05	1.017e-04	

Page : 3
 DOS File: 929899A2.MS5
 Run Date: July 9, 2001
 Run Time: 8:30:35 AM
 Duration: 00:01:12

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		No Buildup MeV/cm ² /sec	With Buildup MeV/cm ² /sec	mR/hr No Buildup	mR/hr With Buildup
0.05	1.435e+05	5.074e-04	8.409e-04	1.352e-06	2.240e-06
0.06	1.729e+06	9.722e-03	1.953e-02	1.931e-05	3.880e-05
0.08	3.073e+05	3.145e-03	7.833e-03	4.977e-06	1.240e-05
0.1	8.546e+05	1.281e-02	3.570e-02	1.959e-05	5.461e-05
0.15	8.724e+03	2.377e-04	7.106e-04	3.915e-07	1.170e-06
0.2	1.696e+05	6.871e-03	2.019e-02	1.213e-05	3.563e-05
0.3	3.306e+03	2.328e-04	6.349e-04	4.417e-07	1.204e-06
0.4	1.476e+05	1.545e-02	3.926e-02	3.011e-05	7.649e-05
0.5	1.736e+05	2.481e-02	5.949e-02	4.869e-05	1.168e-04
0.6	5.437e+08	1.004e+02	2.287e+02	1.959e-01	4.464e-01
0.8	6.589e+05	1.832e-01	3.869e-01	3.485e-04	7.359e-04
1.0	7.938e+05	3.046e-01	6.084e-01	5.615e-04	1.122e-03
1.5	9.243e+05	6.417e-01	1.163e+00	1.080e-03	1.956e-03
TOTALS:	5.949e+08	1.016e+02	2.311e+02	1.983e-01	4.510e-01
	Sensitivity	Variable	X Dose Point 1	(2 of 5)	(10 ft)
0.015	4.023e+01	3.266e-11	3.463e-11	2.801e-12	2.970e-12
0.02	2.861e+03	8.005e-08	8.806e-08	2.773e-09	3.050e-09
0.03	3.639e+07	9.031e-03	1.095e-02	8.951e-05	1.085e-04
0.04	8.962e+06	6.106e-03	8.645e-03	2.700e-05	3.823e-05
0.05	1.435e+05	1.910e-04	3.191e-04	5.088e-07	8.501e-07
0.06	1.729e+06	3.668e-03	7.446e-03	7.286e-06	1.479e-05
0.08	3.073e+05	1.190e-03	3.003e-03	1.883e-06	4.753e-06
0.1	8.546e+05	4.855e-03	1.373e-02	7.427e-06	2.101e-05
0.15	8.724e+03	9.036e-05	2.742e-04	1.488e-07	4.516e-07
0.2	1.696e+05	2.616e-03	7.801e-03	4.618e-06	1.377e-05
0.3	3.306e+03	8.891e-05	2.458e-04	1.687e-07	4.663e-07
0.4	1.476e+05	5.913e-03	1.523e-02	1.152e-05	2.967e-05
0.5	1.736e+05	9.508e-03	2.311e-02	1.866e-05	4.536e-05
0.6	5.437e+08	3.853e+01	8.897e+01	7.520e-02	1.737e-01
0.8	6.589e+05	7.051e-02	1.509e-01	1.341e-04	2.870e-04
1.0	7.938e+05	1.175e-01	2.377e-01	2.165e-04	4.382e-04
1.5	9.243e+05	2.485e-01	4.561e-01	4.182e-04	7.675e-04
TOTALS:	5.949e+08	3.901e+01	8.991e+01	7.614e-02	1.754e-01
	Sensitivity	Variable	X Dose Point 1	(3 of 5)	(13 ft)
0.015	4.023e+01	1.595e-11	1.691e-11	1.368e-12	1.450e-12
0.02	2.861e+03	3.893e-08	4.282e-08	1.348e-09	1.483e-09
0.03	3.639e+07	4.375e-03	5.314e-03	4.336e-05	5.267e-05
0.04	8.962e+06	2.986e-03	4.257e-03	1.320e-05	1.883e-05
0.05	1.435e+05	9.383e-05	1.582e-04	2.500e-07	4.215e-07
0.06	1.729e+06	1.807e-03	3.709e-03	3.589e-06	7.366e-06
0.08	3.073e+05	5.882e-04	1.504e-03	9.308e-07	2.380e-06
0.1	8.546e+05	2.404e-03	6.899e-03	3.678e-06	1.055e-05
0.15	8.724e+03	4.489e-05	1.384e-04	7.392e-08	2.278e-07
0.2	1.696e+05	1.302e-03	3.945e-03	2.299e-06	6.962e-06
0.3	3.306e+03	4.439e-05	1.246e-04	8.421e-08	2.364e-07

Page : 4
 DOS File: 929899A2.MS5
 Run Date: July 9, 2001
 Run Time: 8:30:35 AM
 Duration: 00:01:12

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
			<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.4	1.476e+05	2.959e-03	7.734e-03	5.766e-06	1.507e-05
0.5	1.736e+05	4.767e-03	1.176e-02	9.357e-06	2.307e-05
0.6	5.437e+08	1.935e+01	4.531e+01	3.776e-02	8.844e-02
0.8	6.589e+05	3.550e-02	7.699e-02	6.752e-05	1.464e-04
1.0	7.938e+05	5.928e-02	1.215e-01	1.093e-04	2.240e-04
1.5	9.243e+05	1.260e-01	2.341e-01	2.120e-04	3.939e-04
TOTALS:	5.949e+08	1.959e+01	4.579e+01	3.823e-02	8.935e-02
	<u>Sensitivity</u>	<u>Variable</u>	X Dose Point 1	(4 of 5)	(16 ft)
0.015	4.023e+01	8.457e-12	8.962e-12	7.254e-13	7.687e-13
0.02	2.861e+03	2.164e-08	2.382e-08	7.495e-10	8.251e-10
0.03	3.639e+07	2.493e-03	3.037e-03	2.471e-05	3.010e-05
0.04	8.962e+06	1.719e-03	2.471e-03	7.602e-06	1.093e-05
0.05	1.435e+05	5.427e-05	9.234e-05	1.446e-07	2.460e-07
0.06	1.729e+06	1.048e-03	2.173e-03	2.081e-06	4.317e-06
0.08	3.073e+05	3.420e-04	8.855e-04	5.413e-07	1.401e-06
0.1	8.546e+05	1.401e-03	4.072e-03	2.143e-06	6.230e-06
0.15	8.724e+03	2.622e-05	8.195e-05	4.318e-08	1.349e-07
0.2	1.696e+05	7.622e-04	2.341e-03	1.345e-06	4.132e-06
0.3	3.306e+03	2.605e-05	7.412e-05	4.942e-08	1.406e-07
0.4	1.476e+05	1.740e-03	4.606e-03	3.390e-06	8.974e-06
0.5	1.736e+05	2.808e-03	7.008e-03	5.511e-06	1.376e-05
0.6	5.437e+08	1.141e+01	2.704e+01	2.227e-02	5.277e-02
0.8	6.589e+05	2.098e-02	4.601e-02	3.991e-05	8.752e-05
1.0	7.938e+05	3.510e-02	7.273e-02	6.471e-05	1.341e-04
1.5	9.243e+05	7.488e-02	1.405e-01	1.260e-04	2.364e-04
TOTALS:	5.949e+08	1.155e+01	2.732e+01	2.255e-02	5.331e-02
	<u>Sensitivity</u>	<u>Variable</u>	X Dose Point 1	(5 of 5)	(19 ft)
0.015	4.023e+01	4.827e-12	5.117e-12	4.140e-13	4.389e-13
0.02	2.861e+03	1.322e-08	1.457e-08	4.578e-10	5.047e-10
0.03	3.639e+07	1.576e-03	1.926e-03	1.562e-05	1.909e-05
0.04	8.962e+06	1.099e-03	1.593e-03	4.858e-06	7.044e-06
0.05	1.435e+05	3.483e-05	5.981e-05	9.279e-08	1.593e-07
0.06	1.729e+06	6.741e-04	1.413e-03	1.339e-06	2.807e-06
0.08	3.073e+05	2.206e-04	5.779e-04	3.492e-07	9.145e-07
0.1	8.546e+05	9.050e-04	2.663e-03	1.384e-06	4.075e-06
0.15	8.724e+03	1.699e-05	5.375e-05	2.797e-08	8.852e-08
0.2	1.696e+05	4.946e-04	1.539e-03	8.730e-07	2.716e-06
0.3	3.306e+03	1.695e-05	4.878e-05	3.215e-08	9.253e-08
0.4	1.476e+05	1.134e-03	3.034e-03	2.209e-06	5.912e-06
0.5	1.736e+05	1.832e-03	4.621e-03	3.596e-06	9.070e-06
0.6	5.437e+08	7.455e+00	1.784e+01	1.455e-02	3.482e-02
0.8	6.589e+05	1.374e-02	3.040e-02	2.613e-05	5.781e-05
1.0	7.938e+05	2.302e-02	4.809e-02	4.242e-05	8.865e-05
1.5	9.243e+05	4.924e-02	9.311e-02	8.284e-05	1.566e-04

Page : 5
DOS File: 929899A2.MS5
Run Date: July 9, 2001
Run Time: 8:30:35 AM
Duration: 00:01:12

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec	<u>Fluence Rate</u> MeV/cm ² /sec	<u>Exposure Rate</u> mR/hr	<u>Exposure Rate</u> mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
TOTALS:	5.949e+08	7.549e+00	1.803e+01	1.473e-02	3.518e-02

Appendix F

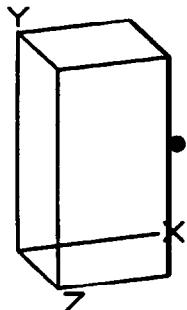
MicroShield Analysis for Iron Thickness Varied versus Exposure Rate for CPP-92, CPP -98, and CPP -99 Waste Stream Soil Box

Microshield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: 929899B2.MS5
Run Date: July 9, 2001
Run Time: 8:48:28 AM
Duration: 00:00:13

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: CP92,98,99Box1inFe
Description: CPP92,98,99-4x4x8Box-1inFeShield-30cmDistance-file:9298B2
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	121.92 cm	4 ft
Width	121.92 cm	4 ft
Height	243.84 cm	8 ft

Dose Points

	X	Y	Z
# 1	1.54e+02 cm 5 ft 0.8 in	121.92 cm 4 ft	60.96 cm 2 ft

Shields

Shield Name	Dimension	Material	Density
Source	128.0 ft	Concrete	1.5
Shield 1	.083 ft	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	bacquerels	$\mu\text{Ci}/\text{cm}^3$	Rq/cm^2
Am-241	1.2680e-004	4.6916e+006	3.4984e-005	1.2944e+000
Ba-137m	1.6320e-002	6.0384e+008	4.5026e-003	1.6660e+002
Cd-113m	1.1420e-006	4.2254e+004	3.1507e-007	1.1658e-002
Co-60	8.1590e-006	3.0188e+005	2.2510e-006	8.3288e-002
Cs-134	1.0880e-006	4.0256e+004	3.0017e-007	1.1106e-002
Cs-135	2.5020e-008	9.2574e+002	6.9029e-009	2.5541e-004
Cs-137	3.5520e-002	1.3142e+009	9.7998e-003	3.6259e+002
Eu-152	9.2460e-008	3.4210e+003	2.5509e-008	9.4385e-004
Eu-154	4.2970e-005	1.5899e+006	1.1855e-005	4.3864e-001
Eu-155	2.6110e-005	9.6607e+005	7.2036e-006	2.6653e-001
H-3	3.4810e-005	1.2880e+006	9.6039e-006	3.5535e-001
I-129	1.6860e-005	6.2382e+005	4.6516e-006	1.7211e-001
Kr-85	7.8330e-004	2.8982e+007	2.1611e-004	7.9960e+000
Nb-93m	9.2460e-009	3.4210e+002	2.5509e-009	9.4385e-005
Np-237	8.1590e-007	3.0188e+004	2.2510e-007	8.3288e-003
Pa-233	3.0460e-008	1.1270e+003	8.4038e-009	3.1094e-004
Pm-147	2.6650e-004	9.8605e+006	7.3526e-005	2.7205e+000
Pu-238	1.3270e-003	4.9099e+007	3.6611e-004	1.3546e+001
Pu-239	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-240	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-241	4.4600e-005	1.6502e+006	1.2305e-005	4.5528e-001
Rh-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Ru-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Sb-125	1.1420e-005	4.2254e+005	3.1507e-006	1.1658e-001

Page : 2
 DOS File: 929899B2.MS5
 Run Date: July 9, 2001
 Run Time: 8:48:28 AM
 Duration: 00:00:13

<u>Nuclide</u>	<u>curies</u>	<u>hecquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Sb-126	1.4690e-008	5.4353e+002	4.0529e-009	1.4996e-004
Sb-126m	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Se-79	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
Sm-151	2.3390e-004	8.6543e+006	6.4532e-005	2.3877e+000
Sn-126	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Sr-90	4.9170e-002	1.8193e+009	1.3566e-002	5.0193e+002
Tc-99	4.0250e-006	1.4893e+005	1.1105e-006	4.1088e-002
Te-125m	1.5770e-006	5.8349e+004	4.3509e-007	1.6098e-002
Th-231	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
U-234	2.7740e-005	1.0264e+006	7.6534e-006	2.8317e-001
U-235	1.2510e-006	4.6287e+004	3.4515e-007	1.2770e-002
U-236	1.4140e-007	5.2318e+003	3.9012e-008	1.4434e-003
Y-90	1.5770e-002	5.8349e+008	4.3509e-003	1.6098e+002
Zr-93	5.9830e-007	2.2137e+004	1.6507e-007	6.1075e-003

Buildup
 The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20
Z Direction	20

Results

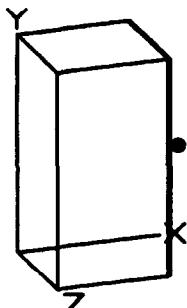
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.023e+01	0.0000e+00	4.205e-32	0.0000e+00	3.607e-33
0.02	2.861e+03	4.843e-228	4.705e-30	1.678e-229	1.630e-31
0.03	3.639e+07	9.967e-73	1.323e-25	9.877e-75	1.312e-27
0.04	8.962e+06	5.478e-34	8.644e-26	2.423e-36	3.823e-28
0.05	1.435e+05	3.880e-21	3.618e-20	1.034e-23	9.638e-23
0.06	1.729e+06	2.207e-13	3.302e-12	4.384e-16	6.558e-15
0.08	3.073e+05	1.458e-08	3.0000e-07	2.307e-11	4.748e-10
0.1	8.546e+05	5.694e-06	1.216e-04	8.712e-09	1.860e-07
0.15	8.724e+03	4.135e-06	6.987e-05	6.809e-09	1.151e-07
0.2	1.696e+05	3.526e-04	4.856e-03	6.223e-07	8.570e-06
0.3	3.306e+03	2.666e-05	2.723e-04	5.058e-08	5.165e-07
0.4	1.476e+05	2.571e-03	2.118e-02	5.009e-06	4.127e-05
0.5	1.736e+05	5.260e-03	3.657e-02	1.032e-05	7.178e-05
0.6	5.437e+08	2.548e+01	1.542e+02	4.973e-02	3.010e-01
0.8	6.589e+05	6.053e-02	2.968e-01	1.151e-04	5.646e-04
1.0	7.938e+05	1.217e-01	5.108e-01	2.244e-04	9.416e-04
1.5	9.243e+05	3.496e-01	1.134e+00	5.881e-04	1.908e-03
TOTALS:	5.949e+08	2.602e+01	1.562e+02	5.067e-02	3.046e-01

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: 929899C2.MS5
Run Date: July 9, 2001
Run Time: 8:50:36 AM
Duration: 00:00:13

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: CP92,98,99Box1.5inFe
Description: CPP92,98,99-4x4x8Box-1.5inFeShield-30cmDistance-file:9298C2
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	121.92 cm	4 ft
Width	121.92 cm	4 ft
Height	243.84 cm	8 ft

Dose Points

#	X	Y	Z
1	1.56e+02 cm 5 ft 1.3 in	121.92 cm 4 ft	60.96 cm 2 ft

Shields

Shield Name	Dimension	Material	Density
Source	128.0 ft ³	Concrete	1.5
Shield 1	.125 ft	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Am-241	1.2680e-004	4.6916e+006	3.4984e-005	1.2944e+000
Ba-137m	1.6320e-002	6.0384e+008	4.5026e-003	1.6660e+002
Cd-113m	1.1420e-006	4.2254e+004	3.1507e-007	1.1658e-002
Co-60	8.1590e-006	3.0188e+005	2.2510e-006	8.3288e-002
Cs-134	1.0880e-006	4.0256e+004	3.0017e-007	1.1106e-002
Cs-135	2.5020e-008	9.2574e+002	6.9029e-009	2.5541e-004
Cs-137	3.5520e-002	1.3142e+009	9.7998e-003	3.6259e+002
Eu-152	9.2460e-008	3.4210e+003	2.5509e-008	9.4385e-004
Eu-154	4.2970e-005	1.5899e+006	1.1855e-005	4.3864e-001
Eu-155	2.6110e-005	9.6607e+005	7.2036e-006	2.6653e-001
H-3	3.4810e-005	1.2880e+006	9.6039e-006	3.5535e-001
I-129	1.6860e-005	6.2382e+005	4.6516e-006	1.7211e-001
Kr-85	7.8330e-004	2.8982e+007	2.1611e-004	7.9960e+000
Nb-93m	9.2460e-009	3.4210e+002	2.5509e-009	9.4385e-005
Np-237	8.1590e-007	3.0188e+004	2.2510e-007	8.3288e-003
Pa-233	3.0460e-008	1.1270e+003	8.4038e-009	3.1094e-004
Pm-147	2.6650e-004	9.8605e+006	7.3526e-005	2.7205e+000
Pu-238	1.3270e-003	4.9099e+007	3.6611e-004	1.3546e+001
Pu-239	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-240	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-241	4.4600e-005	1.6502e+006	1.2305e-005	4.5528e-001
Rh-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Ru-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Sb-125	1.1420e-005	4.2254e+005	3.1507e-006	1.1658e-001

Page : 2
 DOS File: 929899C2.MS5
 Run Date: July 9, 2001
 Run Time: 8:50:36 AM
 Duration: 00:00:13

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Sb-126	1.4690e-008	5.4353e+002	4.0529e-009	1.4996e-004
Sb-126m	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Se-79	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
Sm-151	2.3390e-004	8.6543e+006	6.4532e-005	2.3877e+000
Sn-126	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Sr-90	4.9170e-002	1.8193e+009	1.3566e-002	5.0193e+002
Tc-99	4.0250e-006	1.4893e+005	1.1105e-006	4.1088e-002
Te-125m	1.5770e-006	5.8349e+004	4.3509e-007	1.6098e-002
Th-231	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
U-234	2.7740e-005	1.0264e+006	7.6534e-006	2.8317e-001
U-235	1.2510e-006	4.6287e+004	3.4515e-007	1.2770e-002
U-236	1.4140e-007	5.2318e+003	3.9012e-008	1.4434e-003
Y-90	1.5770e-002	5.8349e+008	4.3509e-003	1.6098e+002
Zr-93	5.9830e-007	2.2137e+004	1.6507e-007	6.1075e-003

Buildup
 The material reference is : Source

Integration Parameters		
X Direction	20	
Y Direction	20	
Z Direction	20	

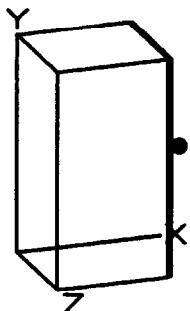
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	Results			
		<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.023e+01	0.000e+00	4.113e-32	0.000e+00	3.528e-33
0.02	2.861e+03	0.000e+00	4.603e-30	0.000e+00	1.594e-31
0.03	3.639e+07	2.940e-107	1.295e-25	2.914e-109	1.283e-27
0.04	8.962e+06	3.086e-49	8.456e-26	1.365e-51	3.740e-28
0.05	1.435e+05	2.376e-29	4.623e-27	6.330e-32	1.232e-29
0.06	1.729e+06	1.886e-18	4.269e-17	3.746e-21	8.479e-20
0.08	3.073e+05	4.164e-11	1.278e-09	6.590e-14	2.023e-12
0.1	8.546e+05	1.331e-07	4.442e-06	2.036e-10	6.795e-09
0.15	8.724e+03	4.935e-07	1.286e-05	8.127e-10	2.118e-08
0.2	1.696e+05	6.710e-05	1.398e-03	1.184e-07	2.467e-06
0.3	3.306e+03	7.137e-06	1.063e-04	1.354e-08	2.016e-07
0.4	1.476e+05	8.054e-04	9.368e-03	1.569e-06	1.825e-05
0.5	1.736e+05	1.825e-03	1.745e-02	3.581e-06	3.425e-05
0.6	5.437e+08	9.530e+00	7.762e+01	1.860e-02	1.515e-01
0.8	6.589e+05	2.528e-02	1.611e-01	4.809e-05	3.063e-04
1.0	7.938e+05	5.507e-02	2.920e-01	1.015e-04	5.383e-04
1.5	9.243e+05	1.801e-01	7.057e-01	3.030e-04	1.187e-03
TOTALS:	5.949e+08	9.793e+00	7.881e+01	1.906e-02	1.536e-01

Microshield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: 929899D2.MS5
Run Date: July 9, 2001
Run Time: 9:02:52 AM
Duration: 00:00:13

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: CP92,98,99-Box-2inFe
Description: CPP92,98,99-4x4x8Box-2inFe Shield-30cmDistance-file:929899D2
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	121.92 cm	4 ft
Width	121.92 cm	4 ft
Height	243.84 cm	8 ft

Dose Points

#	X	Y	Z
1	1.57e+02 cm 5 ft 1.8 in	121.92 cm 4 ft	60.96 cm 2 ft

Shields

Shield Name	Dimension	Material	Density
Source	128.0 ft	Concrete	1.5
Shield 1	.167 ft	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	1.2680e-004	4.6916e+006	3.4984e-005	1.2944e+000
Ba-137m	1.6320e-002	6.0384e+008	4.5026e-003	1.6660e+002
Cd-113m	1.1420e-006	4.2254e+004	3.1507e-007	1.1658e-002
Co-60	8.1590e-006	3.0188e+005	2.2510e-006	8.3288e-002
Cs-134	1.0880e-006	4.0256e+004	3.0017e-007	1.1106e-002
Cs-135	2.5020e-008	9.2574e+002	6.9029e-009	2.5541e-004
Cs-137	3.5520e-002	1.3142e+009	9.7998e-003	3.6259e+002
Eu-152	9.2460e-008	3.4210e+003	2.5509e-008	9.4385e-004
Eu-154	4.2970e-005	1.5899e+006	1.1855e-005	4.3864e-001
Eu-155	2.6110e-005	9.6607e+005	7.2036e-006	2.6653e-001
H-3	3.4810e-005	1.2880e+006	9.6039e-006	3.5535e-001
I-129	1.6860e-005	6.2382e+005	4.6516e-006	1.7211e-001
Kr-85	7.8330e-004	2.8982e+007	2.1611e-004	7.9960e+000
Nb-93m	9.2460e-009	3.4210e+002	2.5509e-009	9.4385e-005
Np-237	8.1590e-007	3.0188e+004	2.2510e-007	8.3288e-003
Pa-233	3.0460e-008	1.1270e+003	8.4038e-009	3.1094e-004
Pm-147	2.6650e-004	9.8605e+006	7.3526e-005	2.7205e+000
Pu-238	1.3270e-003	4.9099e+007	3.6611e-004	1.3546e+001
Pu-239	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-240	1.3430e-004	4.9691e+006	3.7053e-005	1.3710e+000
Pu-241	4.4600e-005	1.6502e+006	1.2305e-005	4.5528e-001
Rh-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Ru-106	8.1590e-009	3.0188e+002	2.2510e-009	8.3288e-005
Sb-125	1.1420e-005	4.2254e+005	3.1507e-006	1.1658e-001

Page : 2
 DOS File: 929899D2.MS5
 Run Date: July 9, 2001
 Run Time: 9:02:52 AM
 Duration: 00:00:13

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Sb-126	1.4690e-008	5.4353e+002	4.0529e-009	1.4996e-004
Sb-126m	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Se-79	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
Sm-151	2.3390e-004	8.6543e+006	6.4532e-005	2.3877e+000
Sn-126	1.0330e-007	3.8221e+003	2.8500e-008	1.0545e-003
Sr-90	4.9170e-002	1.8193e+009	1.3566e-002	5.0193e+002
Tc-99	4.0250e-006	1.4893e+005	1.1105e-006	4.1088e-002
Te-125m	1.5770e-006	5.8349e+004	4.3509e-007	1.6098e-002
Th-231	1.1420e-007	4.2254e+003	3.1507e-008	1.1658e-003
U-234	2.7740e-005	1.0264e+006	7.6534e-006	2.8317e-001
U-235	1.2510e-006	4.6287e+004	3.4515e-007	1.2770e-002
U-236	1.4140e-007	5.2318e+003	3.9012e-008	1.4434e-003
Y-90	1.5770e-002	5.8349e+008	4.3509e-003	1.6098e+002
Zr-93	5.9830e-007	2.2137e+004	1.6507e-007	6.1075e-003

Buildup
 The material reference is : Source

Integration Parameters			
X Direction		20	
Y Direction		20	
Z Direction		20	

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Results</u>			
		<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.023e+01	0.000e+00	4.023e-32	0.000e+00	3.450e-33
0.02	2.861e+03	0.000e+00	4.501e-30	0.000e+00	1.559e-31
0.03	3.639e+07	8.961e-142	1.266e-25	8.881e-144	1.255e-27
0.04	8.962e+06	1.930e-64	8.269e-26	8.536e-67	3.657e-28
0.05	1.435e+05	1.606e-37	4.329e-27	4.279e-40	1.153e-29
0.06	1.729e+06	1.769e-23	6.235e-22	3.513e-26	1.238e-24
0.08	3.073e+05	1.304e-13	5.477e-12	2.063e-16	8.668e-15
0.1	8.546e+05	3.383e-09	1.610e-07	5.175e-12	2.463e-10
0.15	8.724e+03	6.317e-08	2.353e-06	1.040e-10	3.875e-09
0.2	1.696e+05	1.358e-05	3.987e-04	2.397e-08	7.037e-07
0.3	3.306e+03	2.014e-06	4.112e-05	3.821e-09	7.799e-08
0.4	1.476e+05	2.647e-04	4.105e-03	5.158e-07	7.999e-06
0.5	1.736e+05	6.617e-04	8.257e-03	1.299e-06	1.621e-05
0.6	5.437e+08	3.717e+00	3.879e+01	7.254e-03	7.572e-02
0.8	6.589e+05	1.096e-02	8.693e-02	2.085e-05	1.654e-04
1.0	7.938e+05	2.577e-02	1.664e-01	4.750e-05	3.067e-04
1.5	9.243e+05	9.542e-02	4.386e-01	1.605e-04	7.380e-04
TOTALS:	5.949e+08	3.850e+00	3.950e+01	7.485e-03	7.695e-02

Appendix G

Waste Stream CFA-04 Analysis

Appendix G

Waste Stream CFA-04 Analysis

In Sections 5 and 6 in the body of the report, waste streams CPP-92, -98, and -99 are evaluated for the stabilization process. The stabilization process will involve a commercial mixer and will be located in the SSSTF decontamination building. If a particular waste stream has specific activities less than those for waste streams CPP-92, -98, and -99, it falls within the evaluation of waste streams CPP-92, -98, and -99 and needs no further evaluation. If a particular waste stream does not have specific activities less than those for waste streams CPP-92, -98, and -99, then a similar evaluation to the analysis in this appendix should be performed.

All of the specific activities for the waste stream CFA-04 radionuclides are less than those for waste streams CPP-92, -98, and -99, except for those listed in Table G-1.

Table G-1. CF-04 radionuclides and specific activity in excess of those in CPP-92, -98, and -99.

Radionuclide	Specific Activity (pCi/g)	
	CFA-04	CPP-92, -98, and -99
K-40	23.1	none
Ra-226	4.14	none
U-233	1.04	none
U-234	22.6	5.1
U-235	1.6	0.23

In Table G-2, the CFA-04 waste stream was analyzed for external exposure rate. The results are in Table G-3. Appendix G-A contains the output from the MicroShield computer code. In the Table G-4, the CFA-04 waste stream was analyzed for internal dose. The result is 1.48E-2 mrem CEDE as compared to the result for waste streams CPP-92, -98, and -99, which is 0.24 mrem CEDE. To compare results, both cases are for 1400 $\mu\text{g}/\text{m}^3$ contaminated dust concentration. In conclusion, for both external exposure rate and internal dose, waste stream CFA-04 falls within the evaluation of waste streams CPP-92, -98, and -99 and needs no further evaluation.

Table G-2. CFA-04 waste stream evaluation for external exposure rate.

Radionuclide	CFA-04		Worst-Case Specific	
	CWID (pCi/g)	EDF-ER-264 (pCi/g)	Activity (pCi/g)	Activity in 4 × 4 × 8-ft Box (Ci)
H-3	—	1.1E-03	1.1E-03	5.983E-09
K-40	23.1	2.1E+01	23.1	1.256E-04
Co-60	0.025	2.5E-02	2.5E-02	1.360E-07
Kr-85	—	2.5E-02	2.5E-02	1.360E-07
Sr-90	5.39	4.9E-01	5.39	2.932E-05
Y-90	—	4.9E-01	4.9E-01	2.665E-06
Cs-137	1.724	5.3E-01	1.724	9.377E-06
Ba-137m	—	5.0E-01	5.0E-01	2.720E-06
Pm-147	—	8.2E-03	8.2E-03	4.460E-08
Sm-151	—	7.3E-03	7.3E-03	3.970E-08
Eu-154	—	1.3E-03	1.3E-03	7.071E-09
Eu-155	0.051	5.1E-02	5.1E-02	2.774E-07
Ra-226	4.14	1.9E+00	4.14	2.252E-05
U-233/234	1.04	—	NA	NA
U-233	—	—	1.04	5.657E-06
U-234	22.6	—	22.6	1.229E-04
U-235	1.6	2.3E-01	1.6	8.702E-06
U-238	3.500E+01	5.1E+00	3.500E+01	1.904E-04
Pu-241	—	1.4E-03	1.4E-03	7.615E-09

Notes:

Converting pCi/g (soil) to Ci in a 4 × 4 × 8-ft box

Mass (g) of soil in a box:

$$\text{Soil density} = 1.5 \text{ g/cm}^3 \text{ (DOE-ID 1994).}$$

$$1 \text{ cm}^3 = 3.53\text{E-}5 \text{ ft}^3 \text{ (Shleien 1992, p. 47.)}$$

$$1.5 \text{ g/cm}^3 \text{ (soil)} * 4 \text{ ft} * 4 \text{ ft} * 8 \text{ ft} * (\text{cm}^3 / 3.53\text{E-}5 \text{ ft}^3) = 5.439\text{E}6 \text{ g soil.}$$

$$\text{pCi/g (soil)} * 5.439\text{E}6 \text{ g (soil)} * (1\text{E-}12 \text{ Ci} / \text{pCi}) = 5.439\text{E-}6 \text{ Ci-g/pCi.}$$

Multiply pCi/g (soil) by 5.439E-6 Ci-g/pCi to obtain Ci in a 4 × 4 × 8-ft box.

Table G-3. Exposure rate from unshielded box containing contaminated soil.

Distance from Box	Exposure Rate (mR/hr)	
	CFA-04	CPP-92, -98, and -99
0.98 ft (30 cm)	2.9E-3	1.1
3 ft	1.2E-3	0.45
6 ft	4.7E-4	0.18
9 ft	2.4E-4	0.089

Table G-4. SSSTF decon building CFA-04 waste stream internal radiation dose analysis—1,400 mg/m³.

Radionuclide	Specific Activity (pCi/g)	Class	DAC (μCi/cm ³) 10 CFR 835	Air Concentration Worker is Immersed in (μCi/cm ³)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
H-3 ^b	1.1E-03	H ₂ O vapor	2.E-05	1.540E-18	1.73E-11	1.18E-13
K-40	23.1	D	2.E-07	3.234E-14	3.34E-09	4.80E-07
Co-60	2.5E-02	Y	1.E-08	3.500E-17	5.91E-08	9.18E-09
Kr-85 ^c	2.5E-02	—	—	3.500E-17	NA	NA
Sr-90	5.39	Y	2.E-09	7.546E-15	3.51E-07	1.18E-05
Y-90	4.9E-01	Y	2.E-07	6.860E-16	2.28E-09	6.94E-09
Cs-137	1.724	D	7.E-08	2.41E-15	8.63E-09	9.25E-08
Ba-137m ^d	5.0E-01	NA	NA	7.00E-16	NA	NA
Pm-147	8.2E-03	Y	6.E-08	1.148E-17	1.06E-08	5.403E-10
Sm-151	7.3E-03	W	4.E-08	1.02E-17	8.10E-09	3.68E-10
Eu-154	1.3E-03	W	8.E-09	1.82E-18	7.73E-08	6.25E-10
Eu-155	5.1E-02	W	4.E-08	7.14E-17	1.12E-08	3.55E-09
Ra-226	4.14	W	3.E-10	5.80E-15	2.32E-06	5.97E-05
U-233/234	1.04	NA	NA	NA	NA	NA
U-233	1.04	Y	2.E-11	1.46E-15	3.66E-05	2.37E-04
U-234	22.6	Y	2.E-11	4.52E-14	3.58E-05	7.18E-03

Table G-4. (continued).

Radionuclide	Specific Activity (pCi/g)	Class	DAC ($\mu\text{Ci}/\text{cm}^3$) 10 CFR 835	Air Concentration Worker is Immersed in ($\mu\text{Ci}/\text{cm}^3$)	CEDE ^a per Unit Intake Dose Conversion Factor (Sv/Bq) (EPA 1988)	Committed Effective Dose Equivalent (mrem per 1 hr exposure)
U-235	1.6	Y	2.E-11	2.24E-15	3.32E-05	3.30E-04
U-238	3.500E+01	Y	2.E-11	4.90E-14	3.20E-05	6.96E-03
Pu-241	1.4E-03	W	1.E-10	1.96E-18	2.23E-06	1.94E-08
						Total 1.48E-02

- a. CEDE = Committed effective dose equivalent.
- b. DACs and dose conversion factors are for H-3 vapor. No class.
- c. Kr-85 is a noble gas. No internal dose. Minor external dose from submersion.
- d. Ba-137m is included in the Cs-137 DAC and dose conversion factor.

Converting pCi/g (soil) to $\mu\text{Ci}/\text{cm}^3$ (airborne dust)

pCi/g(soil) * airborne dust concentration * 1E-12 Ci/pCi * $\mu\text{Ci}/1\text{E}-6 \text{ Ci}$ => $\mu\text{Ci}/\text{cm}^3$ (airborne dust)

pCi/g(soil) * [1.4000E3 $\mu\text{g}/\text{m}^3$] * [1E-6 g/ μg] * (1E-2 m/cm)³ * [1E-12 Ci/pCi] * [$\mu\text{Ci}/1\text{E}-6 \text{ Ci}$] => $\mu\text{Ci}/\text{cm}^3$ (airborne dust)

pCi/g(soil) * (1.4000E-15 g - $\mu\text{Ci}/\text{pCi} - \text{cm}^3$) => $\mu\text{Ci}/\text{cm}^3$ (airborne dust)

Internal Dose

Internal Radiation Dose = Radioactivity Inhaled During Exposure Time (Intake) * Dose Conversion Factor

Radioactivity Inhaled During Exposure Time (Bq) = Actual Airborne Concentration ($\mu\text{Ci}/\text{cm}^3$) * Volume of Air Breathed in During Exposure Time (cm^3)

Example

U-234

Actual Airborne Concentration = 22.6 pCi/g * (1.4000E-15 g - $\mu\text{Ci}/\text{pCi} - \text{cm}^3$) = 3.164E-14 $\mu\text{Ci}/\text{cm}^3$

Exposure Time = 1 hr

Effective Dose Conversion Factor (W) = 3.58E-5 Sv/Bq (EPA 1988)

Standard Man (ICRP 1975, p. 346) Breathes 20 L/min (Shleien 1992, p. 499)

Radioactivity Inhaled During Exposure Time (Bq) = (3.164E-14 $\mu\text{Ci}/\text{cm}^3$) * (20 L/min) * (mL/1E-3 L) * (cm³/mL) * (1E-6 Ci/ μCi) * ((3.7E10 dis / sec)/Ci) * (Bq/(dis/sec)) * 1 hr * [60 min/hr]

Radioactivity Inhaled During Exposure Time (Bq) = (3.164E-14 $\mu\text{Ci}/\text{cm}^3$) * (4.440E10 Bq-cm³/ μCi) = 1.406E-3 Bq

Radioactivity Inhaled During Exposure Time of One Hour = 1.406E-3 Bq

Effective Dose (rem) = 1.406E-3 Bq * 3.58E-5 Sv/Bq * 100 rem/Sv * [mrem/1E-3 rem] = 5.034E-3 mrem

During Exposure Time of 1 hr => 5.034E-3 mrem

Effective Dose (rem) = (3.164E-14 $\mu\text{Ci}/\text{cm}^3$) * (3.58E-5 Sv/Bq) * (4.440E10 Bq-cm³/ μCi) * (100 rem/Sv) * (mrem /1E-3 rem)

Effective Dose (rem) = (3.164E-14 $\mu\text{Ci}/\text{cm}^3$) * (3.58E-5 Sv/Bq) * 4.440E15 Bq-cm³-mrem/Sv- μCi -hr) = 5.034E-3 mrem

Appendix G-A

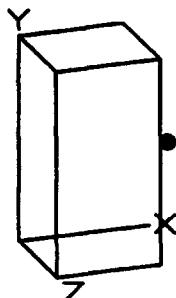
**MicroShield Analysis for Exposure Rate
for Unshielded Box at Various Distances**

MicroShield v5.05 (5.05-00086)
Bechtel Idaho

Page : 1
DOS File: CFA4BOX1.MS5
Run Date: July 30, 2001
Run Time: 1:43:04 PM
Duration: 00:01:07

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: CFA4BoxNoShieldSoil
Description: CFA4-4x4x8Box-NoShield-VariousDistances-file:CFA4BOX2
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	121.92 cm	4 ft
Width	121.92 cm	4 ft
Height	243.84 cm	8 ft

Dose Points

#	X	Y	Z
1	1.52e+02 cm 4 ft 11.8 in	121.92 cm 4 ft	60.96 cm 2 ft

Shields

Shield Name	Dimension	Material	Density
Source	128.0 ft'	Concrete	1.5
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Ba-137m	2.7200e-006	1.0064e+005	7.5044e-007	2.7766e-002
Co-60	1.3600e-007	5.0320e+003	3.7522e-008	1.3883e-003
Cs-137	9.3770e-006	3.4695e+005	2.5871e-006	9.5722e-002
Eu-154	7.0710e-009	2.6163e+002	1.9509e-009	7.2182e-005
Eu-155	2.7740e-007	1.0264e+004	7.6534e-008	2.8317e-003
H-3	5.9830e-009	2.2137e+002	1.6507e-009	6.1075e-005
K-40	1.2560e-004	4.6472e+006	3.4653e-005	1.2821e+000
Kr-85	1.3600e-007	5.0320e+003	3.7522e-008	1.3883e-003
Pm-147	4.4600e-008	1.6502e+003	1.2305e-008	4.5528e-004
Pu-241	7.6150e-009	2.8176e+002	2.1009e-009	7.7735e-005
Ra-226	2.2520e-005	8.3324e+005	6.2132e-006	2.2989e-001
Sm-151	3.9700e-008	1.4689e+003	1.0953e-008	4.0526e-004
Sr-90	2.9320e-005	1.0848e+006	8.0893e-006	2.9930e-001
U-233	5.6570e-006	2.0931e+005	1.5607e-006	5.7747e-002
U-234	1.2290e-004	4.5473e+006	3.3908e-005	1.2546e+000
U-235	8.7020e-006	3.2197e+005	2.4008e-006	8.8831e-002
U-238	1.9040e-004	7.0448e+006	5.2531e-005	1.9436e+000
Y-90	2.6650e-006	9.8605e+004	7.3526e-007	2.7205e-002

Buildup

The material reference is : Source

Integration Parameters

X Direction	20
Y Direction	20
Z Direction	20

Page : 2
 DOS File: CFA4BOX1.MS5
 Run Date: July 30, 2001
 Run Time: 1:43:04 PM
 Duration: 00:01:07

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Results		
			Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.02	4.343e-01	4.535e-11	5.028e-11	1.571e-12	1.742e-12
0.03	5.960e+03	8.578e-06	1.059e-05	8.501e-08	1.049e-07
0.04	3.313e+03	1.403e-05	2.004e-05	6.207e-08	8.862e-08
0.05	5.984e+03	4.966e-05	8.248e-05	1.323e-07	2.197e-07
0.06	6.967e+03	9.207e-05	1.850e-04	1.829e-07	3.675e-07
0.08	1.632e+04	3.933e-04	9.784e-04	6.224e-07	1.548e-06
0.1	3.187e+04	1.126e-03	3.137e-03	1.722e-06	4.799e-06
0.15	4.965e+04	3.193e-03	9.569e-03	5.258e-06	1.576e-05
0.2	2.260e+05	2.162e-02	6.386e-02	3.817e-05	1.127e-04
0.3	5.558e+01	9.254e-06	2.543e-05	1.755e-08	4.823e-08
0.4	1.867e+00	4.624e-07	1.185e-06	9.009e-10	2.309e-09
0.5	2.241e+01	7.581e-06	1.835e-05	1.488e-08	3.602e-08
0.6	9.058e+04	3.964e-02	9.120e-02	7.738e-05	1.780e-04
0.8	1.020e+02	6.737e-05	1.436e-04	1.281e-07	2.731e-07
1.0	5.112e+03	4.665e-03	9.402e-03	8.600e-06	1.733e-05
1.5	5.010e+05	8.295e-01	1.515e+00	1.396e-03	2.549e-03
TOTALS:	9.430e+05	9.004e-01	1.694e+00	1.528e-03	2.881e-03
	Sensitivity	Variable	X Dose Point 1	(1 of 5)	(7 ft)
0.02	4.343e-01	2.883e-11	3.182e-11	9.988e-13	1.102e-12
0.03	5.960e+03	3.949e-06	4.797e-06	3.914e-08	4.754e-08
0.04	3.313e+03	6.021e-06	8.498e-06	2.663e-08	3.758e-08
0.05	5.984e+03	2.116e-05	3.506e-05	5.637e-08	9.341e-08
0.06	6.967e+03	3.917e-05	7.870e-05	7.780e-08	1.563e-07
0.08	1.632e+04	1.671e-04	4.161e-04	2.644e-07	6.585e-07
0.1	3.187e+04	4.777e-04	1.331e-03	7.308e-07	2.037e-06
0.15	4.965e+04	1.353e-03	4.044e-03	2.228e-06	6.659e-06
0.2	2.260e+05	9.158e-03	2.691e-02	1.616e-05	4.749e-05
0.3	5.558e+01	3.915e-06	1.067e-05	7.426e-09	2.025e-08
0.4	1.867e+00	1.954e-07	4.964e-07	3.807e-10	9.671e-10
0.5	2.241e+01	3.201e-06	7.676e-06	6.283e-09	1.507e-08
0.6	9.058e+04	1.672e-02	3.811e-02	3.264e-05	7.438e-05
0.8	1.020e+02	2.837e-05	5.991e-05	5.396e-08	1.140e-07
1.0	5.112e+03	1.962e-03	3.919e-03	3.616e-06	7.223e-06
1.5	5.010e+05	3.478e-01	6.303e-01	5.852e-04	1.060e-03
TOTALS:	9.430e+05	3.777e-01	7.052e-01	6.411e-04	1.199e-03
	Sensitivity	Variable	X Dose Point 1	(2 of 5)	(10 ft)
0.02	4.343e-01	1.215e-11	1.337e-11	4.210e-13	4.631e-13
0.03	5.960e+03	1.479e-06	1.793e-06	1.466e-08	1.777e-08
0.04	3.313e+03	2.257e-06	3.195e-06	9.981e-09	1.413e-08
0.05	5.984e+03	7.965e-06	1.331e-05	2.122e-08	3.545e-08
0.06	6.967e+03	1.478e-05	3.000e-05	2.936e-08	5.959e-08
0.08	1.632e+04	6.321e-05	1.595e-04	1.000e-07	2.524e-07
0.1	3.187e+04	1.811e-04	5.121e-04	2.770e-07	7.835e-07
0.15	4.965e+04	5.143e-04	1.561e-03	8.469e-07	2.570e-06

Page : 3
 DOS File: CFA4BOX1.MS5
 Run Date: July 30, 2001
 Run Time: 1:43:04 PM
 Duration: 00:01:07

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.2	2.260e+05	3.487e-03	1.040e-02	6.155e-06	1.835e-05
0.3	5.558e+01	1.495e-06	4.132e-06	2.836e-09	7.839e-09
0.4	1.867e+00	7.477e-08	1.925e-07	1.457e-10	3.751e-10
0.5	2.241e+01	1.227e-06	2.982e-06	2.408e-09	5.853e-09
0.6	9.058e+04	6.419e-03	1.482e-02	1.253e-05	2.893e-05
0.8	1.020e+02	1.092e-05	2.336e-05	2.077e-08	4.443e-08
1.0	5.112e+03	7.566e-04	1.531e-03	1.395e-06	2.822e-06
1.5	5.010e+05	1.347e-01	2.472e-01	2.267e-04	4.160e-04
TOTALS:	9.430e+05	1.462e-01	2.763e-01	2.481e-04	4.699e-04
	Sensitivity	Variable	X Dose Point 1	(3 of 5)	(13 ft)
0.02	4.343e-01	5.910e-12	6.501e-12	2.047e-13	2.252e-13
0.03	5.960e+03	7.167e-07	8.705e-07	7.103e-09	8.628e-09
0.04	3.313e+03	1.104e-06	1.573e-06	4.881e-09	6.958e-09
0.05	5.984e+03	3.913e-06	6.597e-06	1.042e-08	1.758e-08
0.06	6.967e+03	7.281e-06	1.494e-05	1.446e-08	2.968e-08
0.08	1.632e+04	3.124e-05	7.990e-05	4.944e-08	1.264e-07
0.1	3.187e+04	8.967e-05	2.573e-04	1.372e-07	3.936e-07
0.15	4.965e+04	2.555e-04	7.874e-04	4.207e-07	1.297e-06
0.2	2.260e+05	1.736e-03	5.257e-03	3.064e-06	9.279e-06
0.3	5.558e+01	7.463e-07	2.095e-06	1.416e-09	3.974e-09
0.4	1.867e+00	3.741e-08	9.779e-08	7.290e-11	1.905e-10
0.5	2.241e+01	6.151e-07	1.517e-06	1.207e-09	2.977e-09
0.6	9.058e+04	3.223e-03	7.549e-03	6.291e-06	1.474e-05
0.8	1.020e+02	5.497e-06	1.192e-05	1.046e-08	2.268e-08
1.0	5.112e+03	3.818e-04	7.828e-04	7.038e-07	1.443e-06
1.5	5.010e+05	6.828e-02	1.269e-01	1.149e-04	2.135e-04
TOTALS:	9.430e+05	7.402e-02	1.416e-01	1.256e-04	2.408e-04
	Sensitivity	Variable	X Dose Point 1	(4 of 5)	(16 ft)
0.02	4.343e-01	3.285e-12	3.616e-12	1.138e-13	1.253e-13
0.03	5.960e+03	4.083e-07	4.974e-07	4.047e-09	4.930e-09
0.04	3.313e+03	6.353e-07	9.133e-07	2.810e-09	4.039e-09
0.05	5.984e+03	2.263e-06	3.850e-06	6.028e-09	1.026e-08
0.06	6.967e+03	4.222e-06	8.758e-06	8.385e-09	1.739e-08
0.08	1.632e+04	1.817e-05	4.704e-05	2.875e-08	7.443e-08
0.1	3.187e+04	5.223e-05	1.519e-04	7.991e-08	2.323e-07
0.15	4.965e+04	1.492e-04	4.664e-04	2.458e-07	7.680e-07
0.2	2.260e+05	1.016e-03	3.121e-03	1.793e-06	5.508e-06
0.3	5.558e+01	4.380e-07	1.246e-06	8.308e-10	2.364e-09
0.4	1.867e+00	2.200e-08	5.824e-08	4.287e-11	1.135e-10
0.5	2.241e+01	3.623e-07	9.043e-07	7.111e-10	1.775e-09
0.6	9.058e+04	1.901e-03	4.505e-03	3.710e-06	8.792e-06
0.8	1.020e+02	3.249e-06	7.125e-06	6.180e-09	1.355e-08
1.0	5.112e+03	2.261e-04	4.684e-04	4.168e-07	8.635e-07
1.5	5.010e+05	4.058e-02	7.615e-02	6.828e-05	1.281e-04

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 DOS File: CFA4BOX1.MS5
 Run Date: July 30, 2001
 Run Time: 1:43:04 PM
 Duration: 00:01:07

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
TOTALS:	9.430e+05	4.396e-02	8.493e-02	7.459e-05	1.444e-04
	Sensitivity	Variable	X Dose Point 1	(5 of 5)	(19 ft)
0.02	4.343e-01	2.007e-12	2.212e-12	6.951e-14	7.662e-14
0.03	5.960e+03	2.582e-07	3.155e-07	2.559e-09	3.127e-09
0.04	3.313e+03	4.060e-07	5.887e-07	1.796e-09	2.604e-09
0.05	5.984e+03	1.452e-06	2.494e-06	3.869e-09	6.644e-09
0.06	6.967e+03	2.716e-06	5.694e-06	5.395e-09	1.131e-08
0.08	1.632e+04	1.172e-05	3.070e-05	1.855e-08	4.858e-08
0.1	3.187e+04	3.375e-05	9.934e-05	5.164e-08	1.520e-07
0.15	4.965e+04	9.667e-05	3.059e-04	1.592e-07	5.038e-07
0.2	2.260e+05	6.592e-04	2.051e-03	1.164e-06	3.620e-06
0.3	5.558e+01	2.849e-07	8.201e-07	5.404e-10	1.556e-09
0.4	1.867e+00	1.434e-08	3.837e-08	2.793e-11	7.476e-11
0.5	2.241e+01	2.364e-07	5.962e-07	4.640e-10	1.170e-09
0.6	9.058e+04	1.242e-03	2.972e-03	2.424e-06	5.801e-06
0.8	1.020e+02	2.127e-06	4.707e-06	4.046e-09	8.952e-09
1.0	5.112e+03	1.482e-04	3.097e-04	2.732e-07	5.710e-07
1.5	5.010e+05	2.669e-02	5.047e-02	4.490e-05	8.491e-05
TOTALS:	9.430e+05	2.889e-02	5.625e-02	4.901e-05	9.564e-05